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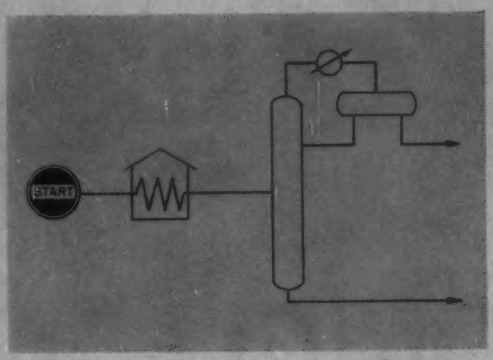
Petroleum Refiner

Gulf Publishing Company

SEPTEMBER
1957

Latest Process Developments



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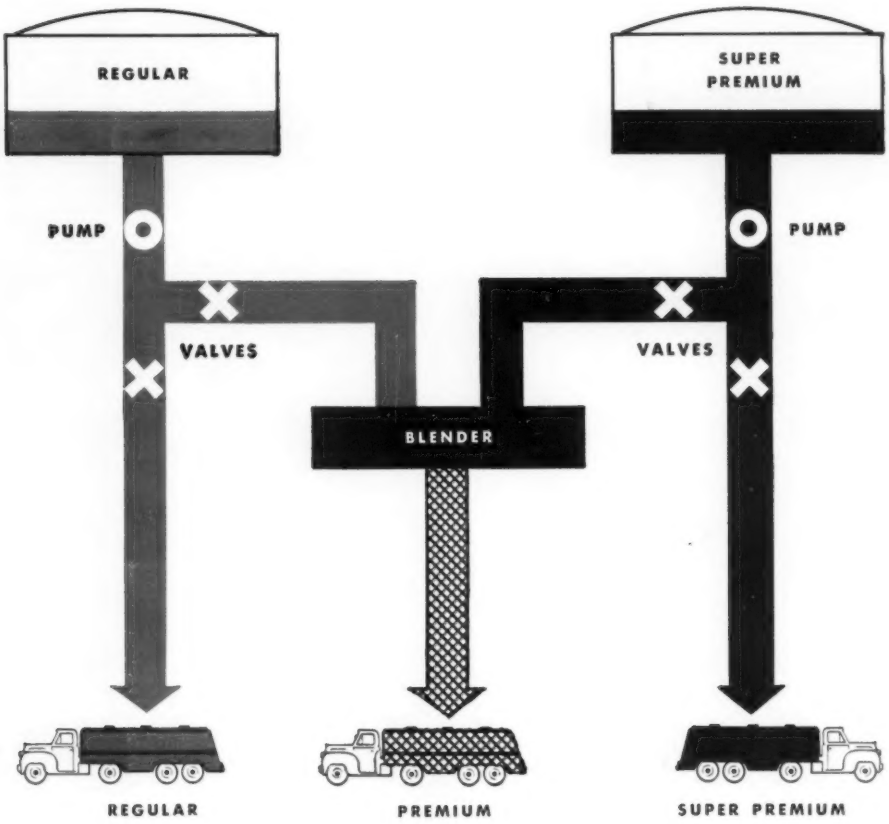

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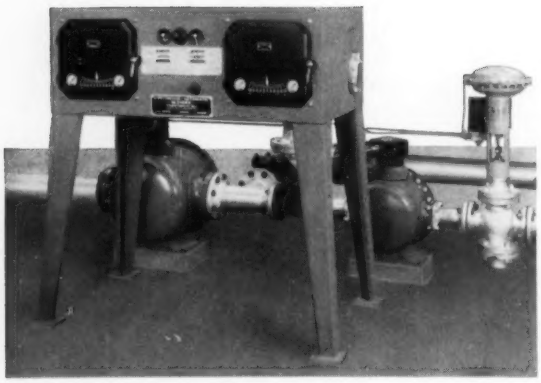

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Petroleum Refiner

REFINING • PETROCHEMICALS • NATURAL GASOLINE

A Quick Look

at This Issue

These handy digests permit checking ☑ the articles you want to read first.

☐ **Now You Can Hydrocrack Asphaltic Crudes** . . . Here are data on a new process developed in Hungary. They show how to upgrade asphaltic crudes by cracking in a hydrogen atmosphere and in the presence of a catalyst. For both laboratory and pilot plant information, turn to **Page 198.**

☐ **This New Process Handles Residuals** . . . This is the new "H-Oil" hydrogenation process. With the continuing drop in value for heavy residual stocks, you will want to see how they can be hydrogenated into useful products. Turn to **Page 201.**

☐ **Hydrocrack and Gasify to Upgrade Stocks** . . . Here are data on hydrocracking and hydrogasification. They show how hydrocracking may be used to produce: (1). Aromatics for motor fuel blending. (2). A stock suitable for conversion to a natural gas substitute. Turn to **Page 205.**

☐ **Coking Shifts Product Distribution** . . . Fluid coking eliminates some residual fuel oil and increases the production of gasoline and distillate. See how the process works and examine some of the uses for the by-product coke. Turn to **Page 211.**

☐ **Isom Process Gives High Road Octanes** . . . High octane motor fuels may be obtained by isomerizing pentanes and hexanes with the new Iso-Kel process. Here are data on laboratory and road ratings of isomerized products. They will help determine the value of isomerization in your refinery scheme. Turn to **Page 215.**

☐ **Data on Latest Reforming Process** . . . Powerforming is the newest catalytic reforming process. For complete data on how the process handles various feed stocks, plus the way in which product yield is related to reforming severity, turn to **Page 221.**

☐ **The New Look in Butane Isomerization** . . . Here are changes Shell made in its liquid-phase isomerization process. With the addition of a compressor for hydrogen recycle, the revamped process can also be used to isomerize pentanes. **Page 223.**

Please Turn Page ➜

A Quick Look at This Issue . . .

☐ **How to Treat Alkylate** . . . Having trouble with fouling? Here is a company that was unable to find a proper fouling inhibitor for its sulfuric acid alkylation plant. Instead, bauxite filter towers are used to treat the reactor effluent. **Page 266.**

☐ **New Way to Stability: Continuous Percolation** . . . Now some of the principles of a countercurrent flow system have been applied to an adsorbent bed. See how this new percolation process works by turning to **Page 229.**

☐ **Treat for Nitrogen Base Removal** . . . Ohio Oil is the first to use an Electrofiner for nitrogen base removal. How spent alkylation acid and untreated subsurface water are used to treat a coker naphtha is described on **Page 231.**

☐ **Hydrogen Treat Wide Range of Stocks** . . . Here are results you will get from the Hydrofining process. Data include the effect of treating stocks from naphthas to waxes. Compare them with your own product quality. **Page 233.**

☐ **New Way to Get Oil-Free Wax** . . . The cost to build a plant using this new spray de-oiling process would be about $40 per annual ton of paraffin wax charge. Compare its operation with your present process. Turn to **Page 236.**

☐ **Baghdad's New Lube Plant Uses Furfural Refining** . . . One of the features of the Iraq government's new plant is the use of a rotating disc contactor in the furfural refining unit. For a detailed description, turn to **Page 239.**

☐ **They Use Benzene-Acetone to Dewax** . . . While a large number of refineries are trying to make very low pour point oils, others do not have these strict requirements. Here is a description of a refinery in Greece which uses a benzene-acetone solvent to accomplish dewaxing. Turn to **Page 241.**

☐ **Nuclear Reactor Seen as Process Tool** . . . Here is a timely discussion of nuclear reactor products, plus ways in which they can be applied to refining. For the outlook on nuclear reactor use in future refining operations, turn to **Page 243.**

☐ **Process Design Primer** . . . This 18-page report is designed for the new process engineer, the chemist, the mechanical engineer, and the chemical engineer. It will tell you where process design starts and ends, how to take the first steps in design, and how to estimate plant costs and profits. You'll want to save this report. **Page 249.**

☐ **Scale-Up Equipment** . . . There's more to scaling up equipment than meets the eye at first glance. You'll want to study these six articles to make the job easier. The first article tells the economics involved. Then, the theories are applied to these specific items of equipment: rotating disc contactors, reactors, continuous filters, adsorption columns and cyclones. Start reading on **Page 267.**

☐ **How Engineer-Contractors Handle a Job** . . . How can an engineer-contractor help you? Understanding the steps followed in developing an inquiry into a finished plant can help you take advantage of his services. Careful study of his specialized engineering functions may help you in planning your next project. Turn to **Page 277.**

☐ **Petrochemicals from Resid** . . . In natural-gas-poor Japan the Tsutsumi vacuum cracking process offers great promise for making petrochemicals directly from oil. Using a moving bed and heavy oils the process offers a new source of olefin rich gas. Add this to your process notebook. Turn to **Page 286.**

☐ **Predicting V—L Equilibrium Data** . . . Are you looking for equilibrium data not reported in the literature? Then the methods in these three articles will help you shorten time in process calculations. The first, an activity coefficient method developed for binaries and multicomponent systems, is good for temperatures and pressures below the critical point. The second is also an activity coefficient method but it requires only one point of experimental data and is good at constant pressures for binary mixtures. The third method is graphical and is good at constant temperatures for binaries. You'll want to save all three. Turn to **Page 291.**

☐ **Particle Size Affects Fluidization** . . . The key to better understanding of many of the perplexing observations on fluidization lies in the definition of the bed composition. Here is an interpretation of incipient fluidization deduced from particle size and distribution considerations. Study this along with Part 2 for a complete discussion of the affects of particle size distribution. Turn to **Page 305.**

☐ **Threatened With Power Failure?** . . . Refining and petrochemical processes demand a high degree of electric service continuity. Here's an outline of critical, electrical equipment problems and how to cure them. For complete details, turn to **Page 309.**

☐ **Automation Today (Part 12)** . . . Computers can simulate the operation of refining equipment. But first, it may be wise to review how mathematical equations are represented by computer components. The more commonly used computer operations are discussed in the article starting on **Page 315.**

☐ **What To Do About Hydrogen Blistering** . . . Here's how Richfield tackled the problem of hydrogen blistering in their fluid catalytic cracking unit. They found that most of the corrosive constituants could be removed by applying an extensive water wash in the main fractionator overhead. For complete details, turn to **Page 319.**

Petroleum Refiner

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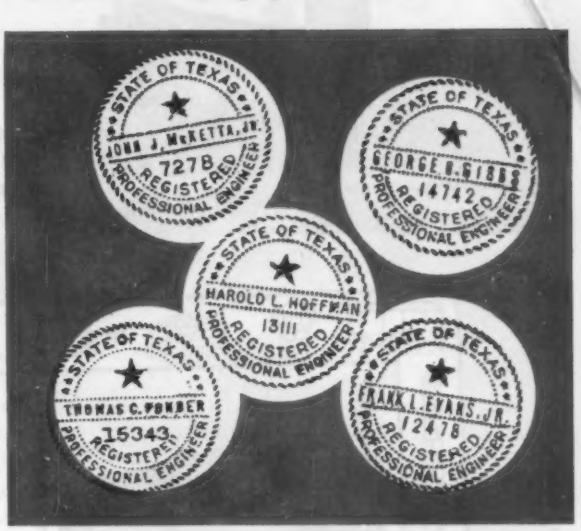

LAST MONTH Tom Ponder received his registration as a Professional Engineer in the State of Texas. That makes registration of engineers on PETROLEUM REFINER 100 percent. Chairman of the Editorial Committee John J. McKetta, Editor George B. Gibbs, Process and Construction Editor Harold Hoffman, and Maintenance and Design Editor Frank Evans already had their registration. It means that articles appearing in PETROLEUM REFINER are checked by registered engineers. For our readers it's a seal of approval of which we're quite proud.

A Cheerful Earful!

OUR RESEARCH DEPARTMENT, with the cooperation of a score or more top men in integrated oil companies and engineer-constructor firms, has come up with some mighty interesting figures on the processing industry's prospective spending. Here, for instance, is the information representing the **increase percentages for next year compared with 1957's record levels for CAPITAL SPENDING:**

	Refining	Petrochemicals	Natural Gasoline
For the U.S.A.	Up 6%	Up 21.5%	Up 15.8%
Other Countries	Up 12%	Up 33.0%	Up 12.5%

The gross industry spending in 1958 for new plant, facilities, maintenance of plant, purchase of operating supplies, chemicals, containers, etc., will be $6.6 billion. Of this amount $4.4 billion will be for materials, equipment and supplies purchased from manufacturers.

What a promising future, especially for equipment manufacturers and suppliers!

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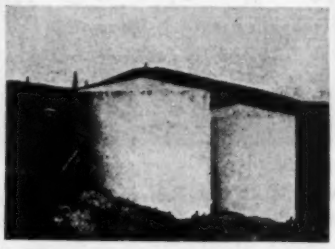

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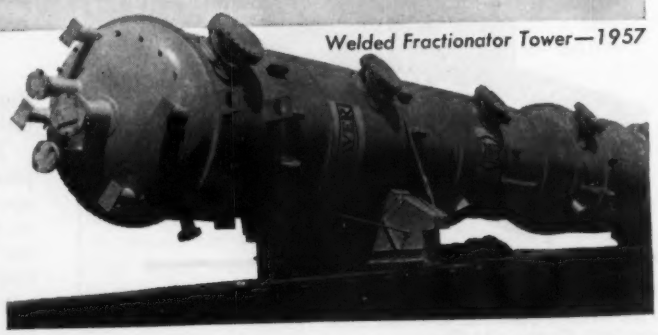
Some of the many types of riveted fabrication by Graver, as advertised in National Petroleum News, July, 1913

Welded Fractionator Tower—1957



Joining plate with rivets for processing equipment, pressure vessels and storage tanks would be quite unsatisfactory today. Yet, before welding became an accepted fabricating technique, to which Graver contributed measurably in perfecting, Graver's boring and riveting methods were recognized as the most advanced in the country. Today, the most advanced welding, X-ray testing, stress-relieving and assembly methods are employed. This is what you can always expect from Graver—a pioneer in skilled steel and alloy fabrication for 100 years!

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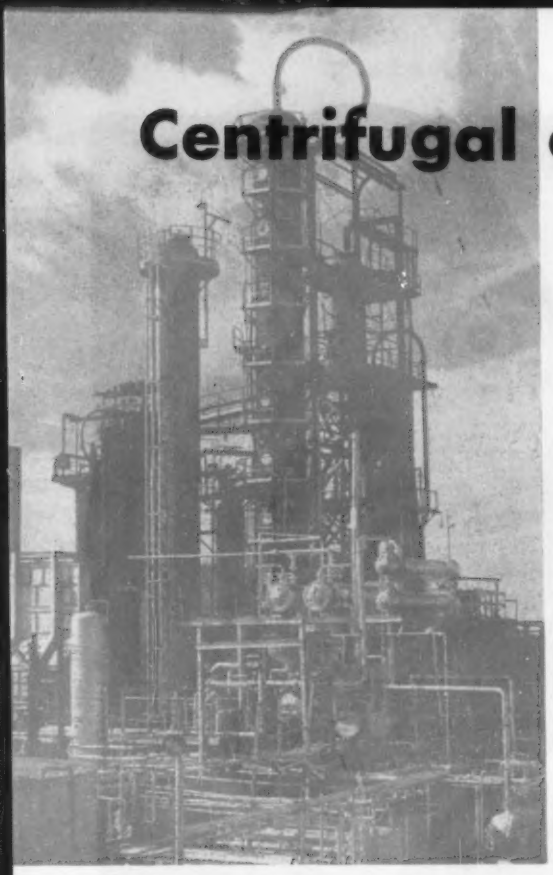
For more data on advertised products, use Readers' Service Cards, last page.



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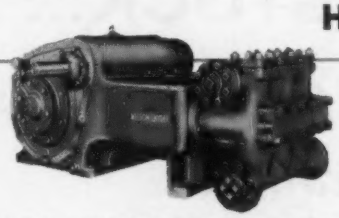
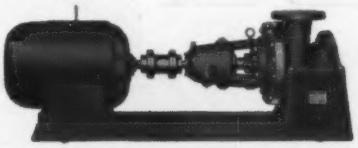
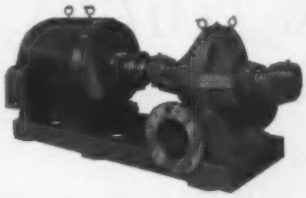
Here are Four Popular Types



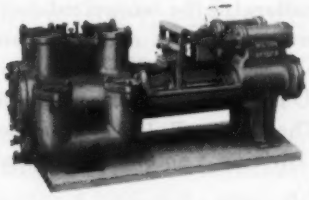
TRIPLEX PLUNGER-TYPE POWER PUMPS . . . Designed for handling a wide range of products, including highly volatile liquids over a wide temperature range, and time-proven in high-pressure charge pump service. Available in 4", 6" and 8" stroke sizes for capacity requirements up to 500 GPM and pressures up to 5,650 psi.



ES CENTRIFUGAL PROCESS PUMPS . . . Single or two-stage heavy-duty type for elevated temperature applications to 900°F., employing vertically split case and single stuffing box for conventional packing or mechanical seal of your choice. End suction, as illustrated, is standard construction—can also be furnished with top suction when preferred. Twenty sizes provide capacities from 15 to 2,000 GPM, 50 to 1100-ft. head, 2 to 250 HP.



DOUBLE SUCTION CENTRIFUGAL PUMPS . . . Single-stage heavy-duty type for temperature applications to 300°F., employing horizontally split case with impeller mounted between bearings. Side suction and side discharge arrangement is standard—bottom suction arrangement is available in 14" and larger sizes. Fourteen sizes provide capacities from 100 to 30,000 GPM, 20 to 300-ft. head, 5 to 1,500 HP.



DUPLEX PISTON-TYPE DIRECT-ACTING STEAM PUMPS . . . Designed for handling a wide range of products for all general service requirements, including the handling of volatile liquids over a wide temperature and pressure range. Available in stroke lengths from 6" to 24" for capacity requirements to 1800 GPM and pressures to 800 psi.

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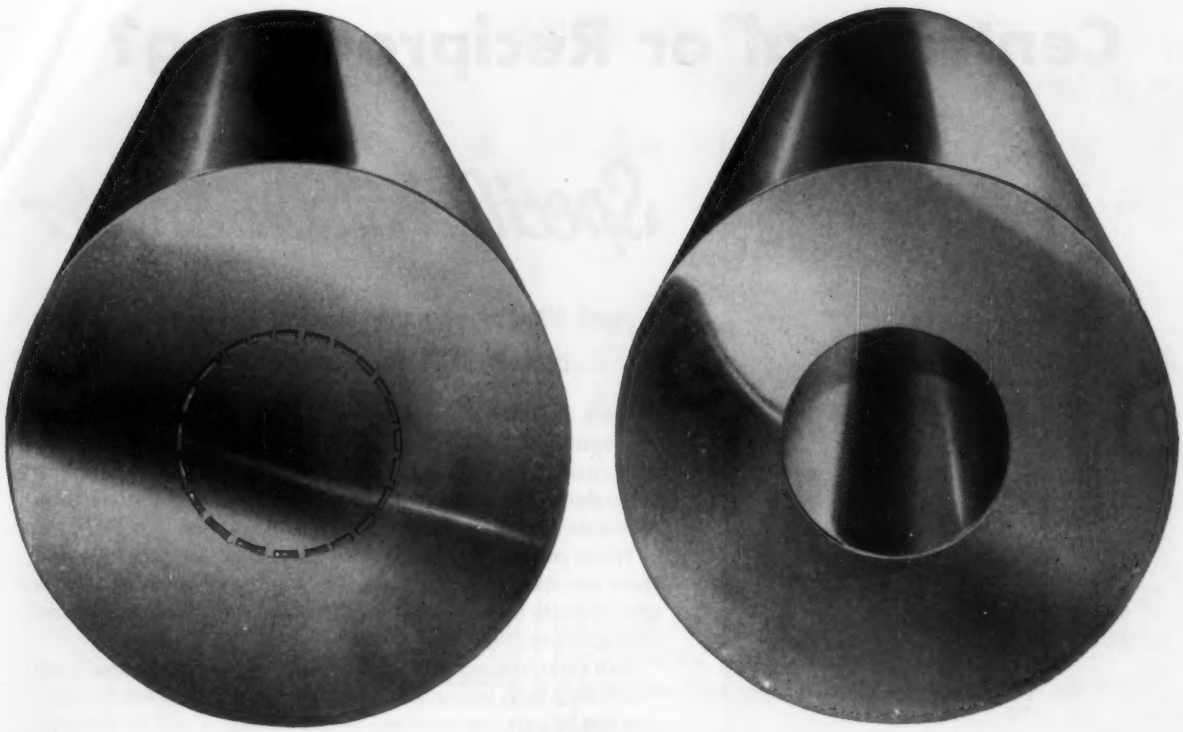
USS TRADE MARK

"OILWELL" TRADE MARK

UNITED STATES STEEL



WHY BORE OUT BAR STOCK...

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For more data on advertised products, use Readers' Service Cards, last page.

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JM-3000 for temperatures to 3000F exposed
JM 28
JM-28 for temperatures to 2800F exposed
JM 26
JM-26 for temperatures to 2600F exposed
JM 23
JM-23 for temperatures to 2300F exposed
Which insulating firebrick best meets your needs?
JM 20
JM-20 for temperatures to 2000F exposed
JM 1620
JM-1620 for temperatures to 1600F exposed; to 2000F back-up
SIL-O-CEL 16 L
Sil-O-Cel 16 L for temperatures to 1600F, back-up or exposed
SIL-O-CEL C-22
Sil-O-Cel C-22 for temperatures to 2000F, back-up
SIL-O-CEL SUPER
Sil-O-Cel Super for temperatures to 2500F, back-up

Only Johns-Manville's insulating brick family offers the right combination of properties . . . *for furnace requirements to 3000F!*

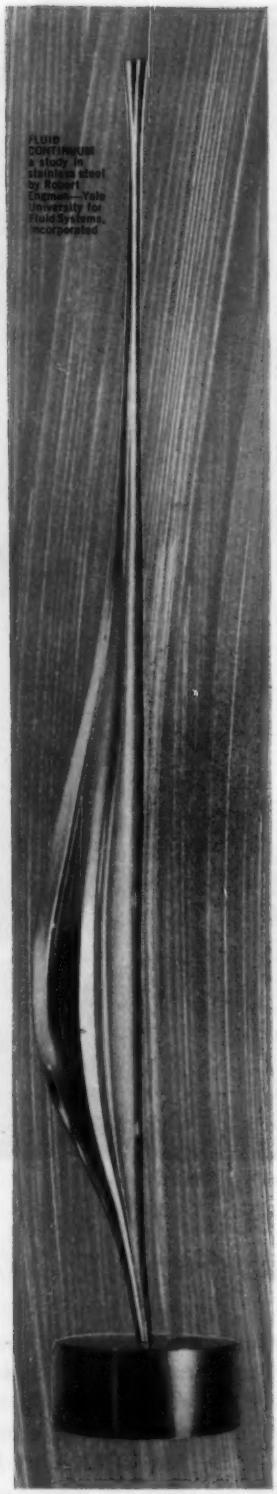
J-M's nine *different* insulating firebrick* means you never have to settle for a brick that's nearly right! Instead, you choose the one brick that best meets your needs . . . for such important properties as temperature resistance, load-bearing strength, conductivity and density.

Johns-Manville has two strategically located plants for the production of insulating brick: Lompoc, California, and Zelienople, Pennsylvania. Brick are available from the stocks of authorized Johns-Manville distributors in key industrial areas.

For information on insulating firebrick as well as hydraulic-setting refractories, write for brochures IN-115A and RC-28A to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ont.

**Sil-O-Cel® Super and C-22 insulating brick are for back-up use only*

Johns-Manville REFRACTORY AND INSULATING REFRACTORY PRODUCTS



*INCREASE **ASPHALT** TERMINAL PRODUCTION AND ELIMINATE STEAM TRACER LINES WITH A MODERN*

THERMAL ELECTRIC® SYSTEM

Modern Thermal Electric guarantees even, dependable heat along the entire length of an asphalt pipe line — at extremely low cost. Lines can now be left full, ready for immediate delivery of asphalt to any point in the system.

Thermal Electric pipeline heating is accomplished by impressing controlled increments of low voltage, 60 cycle alternating current on the same pipe in which the asphalt is contained.

ALL STEAM TRACING IS ELIMINATED. Reduce boiler capacity — do away with the costly maintenance of tracer lines, traps and valves. Eliminate forever the double danger of freeze ups — or coking due to localized hot spots.

MAINTENANCE COST ALMOST ZERO. Thermal Electric is an automatic, all-electric operation. There are no moving parts to wear out or fail. Constant pipe temperature regardless of varying ambient temperatures eliminates "working" of the line. Many long time users have reported "No pipeline maintenance costs over a period of years."

100% AUTOMATIC OPERATION. A 60 cycle current of 24 volts or less is impressed on the fluid conveying pipe through one or more Thermal Electric Energizers. Remote thermostats monitor the pipe temperature and maintain that temperature to a 5° F differential under all conditions. Once put into operation, no further adjustment or surveillance is required.

LOW HEAT DENSITY SAVES DOLLARS. Since the entire pipe wall is evenly heated, watt densities are minute. Pipelines can be left full during shutdown periods without any danger of coking. If the shutdown is expected to be for an extended period, the System can be shut off. Thermal Electric is guaranteed to melt out the line and restore normal temperatures — without affecting the product in any way.

Of course, each Thermal Electric System is designed for your specific application. Fluid Systems engineers have for 20 years specialized in the design of viscous fluid storage and pipeline heating. 100% automatic, low cost operation and zero maintenance costs are the natural result of simplified hydraulics and reduced equipment requirements.

For additional Thermal Electric information, write today. Customer lists and performance records are readily available.

Trademarks Reg. U.S. Pat. Off.

FLUID SYSTEMS INC.

1881 DIXWELL AVENUE • NEW HAVEN 14 • CONNECTICUT

NEW YORK • NEW HAVEN • CHICAGO

Fluid Systems INC.

Designed and constructed by Foster Wheeler for the American Gilsonite Company* at Gilsonite, Colorado, this combination delayed coking and thermal cracking unit is converting 700 tons per day of Gilsonite into 50 per cent Coke (350 tons per day), 15 per cent Gas and 35 per cent Gasoline. This installation marks the first commercially successful conversion of a solid asphaltic-type ore into salable products.

**Affiliate of Barber Oil Corporation and Standard Oil Company of California*

FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.

AMERICAN
AIR LIQUIDE
ENGINEERING & CONSTRUCTION DIVISION

OLDEST IN EXPERIENCE—NEWEST IN DESIGN

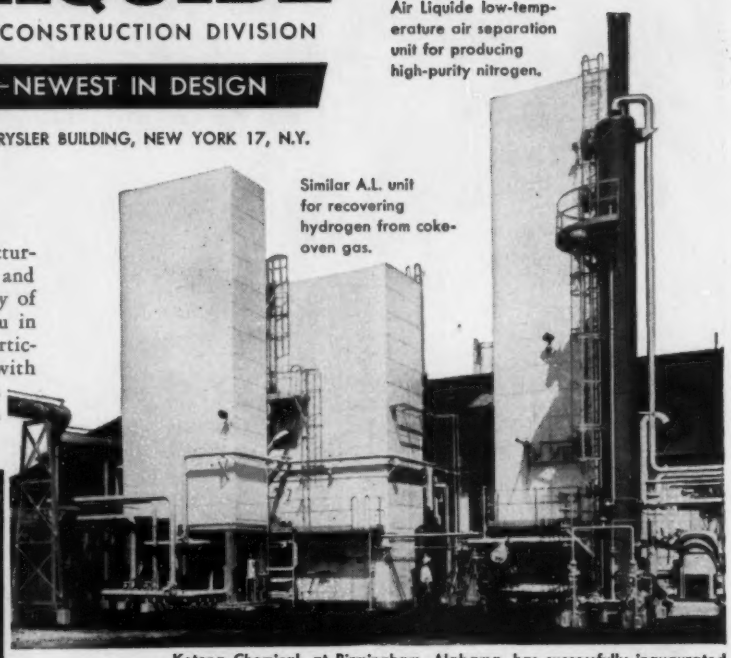
529 CHRYSLER BUILDING, NEW YORK 17, N.Y.

In Canada: **L'Air Liquide**
1111 Beaver Hall Hill
Montreal, Que.

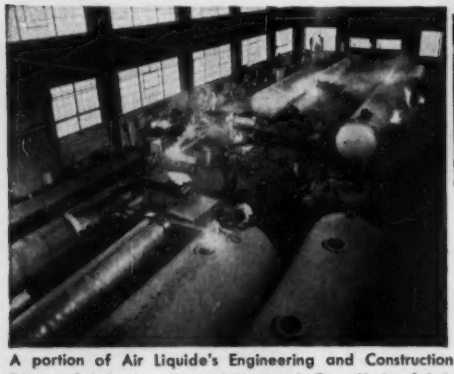
Our widely-experienced technical and manufacturing staff, including design, process, project and mechanical engineers, backed by half a century of "know-how," is at your service to assist you in applying low-temperature technology to your particular requirements. We shall be glad to consult with you regarding cost analyses and technical aspects in the design and manufacture of complete plants or components "tailored" to your needs.

Air Liquide low-temperature air separation unit for producing high-purity nitrogen.

Similar A.L. unit for recovering hydrogen from coke-oven gas.



Ketona Chemical, at Birmingham, Alabama, has successfully inaugurated the first ammonia plant in this country designed exclusively around coke-oven gas as a source of hydrogen. The low-temperature gas separation units used at Ketona were designed and built by American Air Liquide.

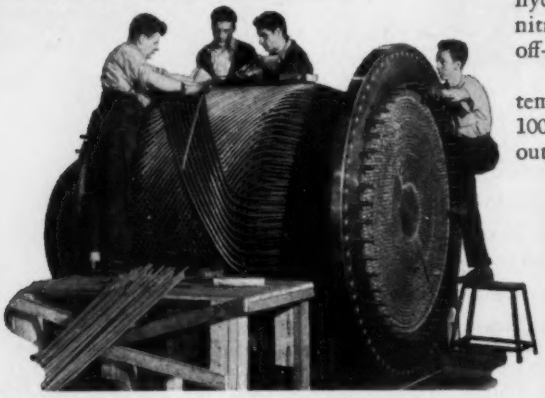


A portion of Air Liquide's Engineering and Construction Division fabricating plant at Montreal, Que. Under fabrication here are numerous all-welded stainless steel shells to house component exchangers, vaporizers, rectification columns, etc., of the liquefaction equipment.

Low-temperature separation processes, for recovering atmospheric and hydrocarbon gases in tonnage quantities, are being used on a rapidly increasing scale in the United States.

Once confined to the separation of oxygen, nitrogen and the rare gases of the atmosphere, the low-temperature liquefaction process of separation is today successfully producing high-purity hydrogen, pure carbon monoxide, methane, ethylene, propane and nitrogen, from such gaseous mixtures as: natural gas, refinery off-gases and coke-oven gas.

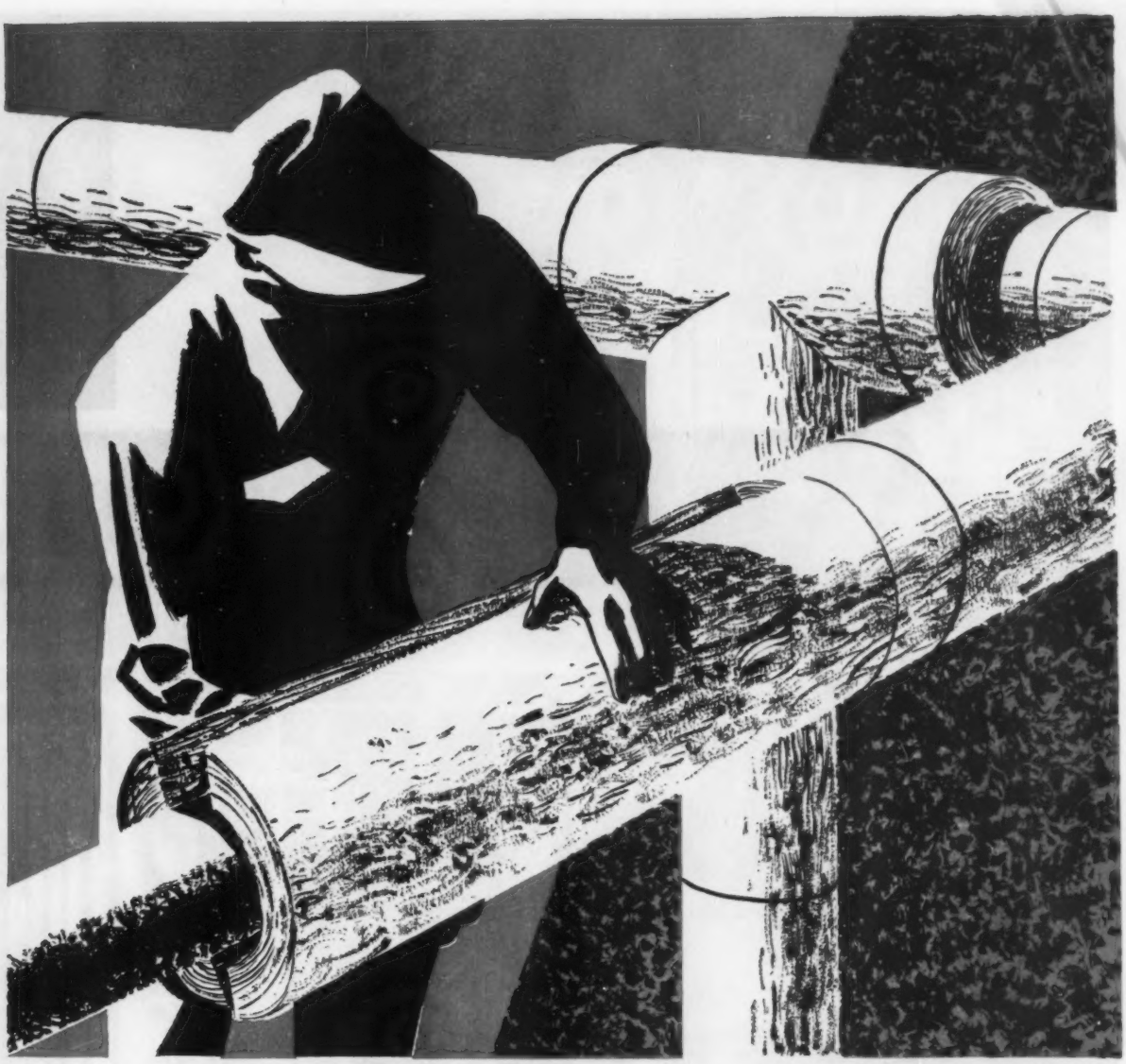
During the past 50 years, Air Liquide (a pioneer in the low-temperature gas separation field) has designed and built more than 1000 hydrocarbon and air-separation plants for industries throughout the world. In the United States it is a leader in this field.



The fabrication of an Air Liquide wound tube-type exchanger can involve over 10 miles of intimately interwoven copper tubing to provide the necessary cooling surfaces in this specialized low-temperature equipment.

Centre of control panel for a large-tonnage oxygen plant includes a flow sheet for the operator's guidance. Once put "on stream", operation of Air Liquide low-temperature plants is almost entirely automatic.

L'Air Liquide, its affiliates and subsidiaries have offices and plants throughout the world: Algeria, Argentina, Belgium, Brazil, Cameroon, Canada, China, Egypt and Sudan, France, French Congo, French West Africa, Gold Coast, Great Britain, Greece, Indochina, Italy, Ivory Coast, Japan, Lebanon, Luxemburg, Madagascar, Malay States, Morocco, Netherlands, Paraguay, Portugal, Siam, South Africa, South-East Asia, Spain, Sweden, Syria, Tunisia, and the United States of America.



Efficient hot line insulation is lightweight, easy to handle

Specially designed for hot lines operating up to 400°F., Armstrong Armaglas* Pipe Covering goes on fast, provides extra-efficient protection. Armaglas is made of glass fibers bonded together with a heat-resistant resin; it has a density of only 7¼ lbs. per cubic foot for light, easy handling. The resilient fibers mesh together at joints to give unbroken, continuous protection.

Armaglas Pipe Covering comes in 3′ sections for pipe sizes up to 33″ and copper tubing up to 6″. It is available with a variety of interior and exterior type jackets.

Armaglas Pipe Covering is one of the many fine products in the complete line of Armstrong Industrial Insulations. Armstrong also offers you a contracting service, geared to install these products efficiently.

Armstrong INSULATIONS

for temperatures from −300° F. to +2800° F.

*® ARMSTRONG CORK COMPANY. MANUFACTURED BY OWENS-CORNING FIBERGLAS CORP.

Free Booklets

Armstrong Armaglas Insulations (data sheets)

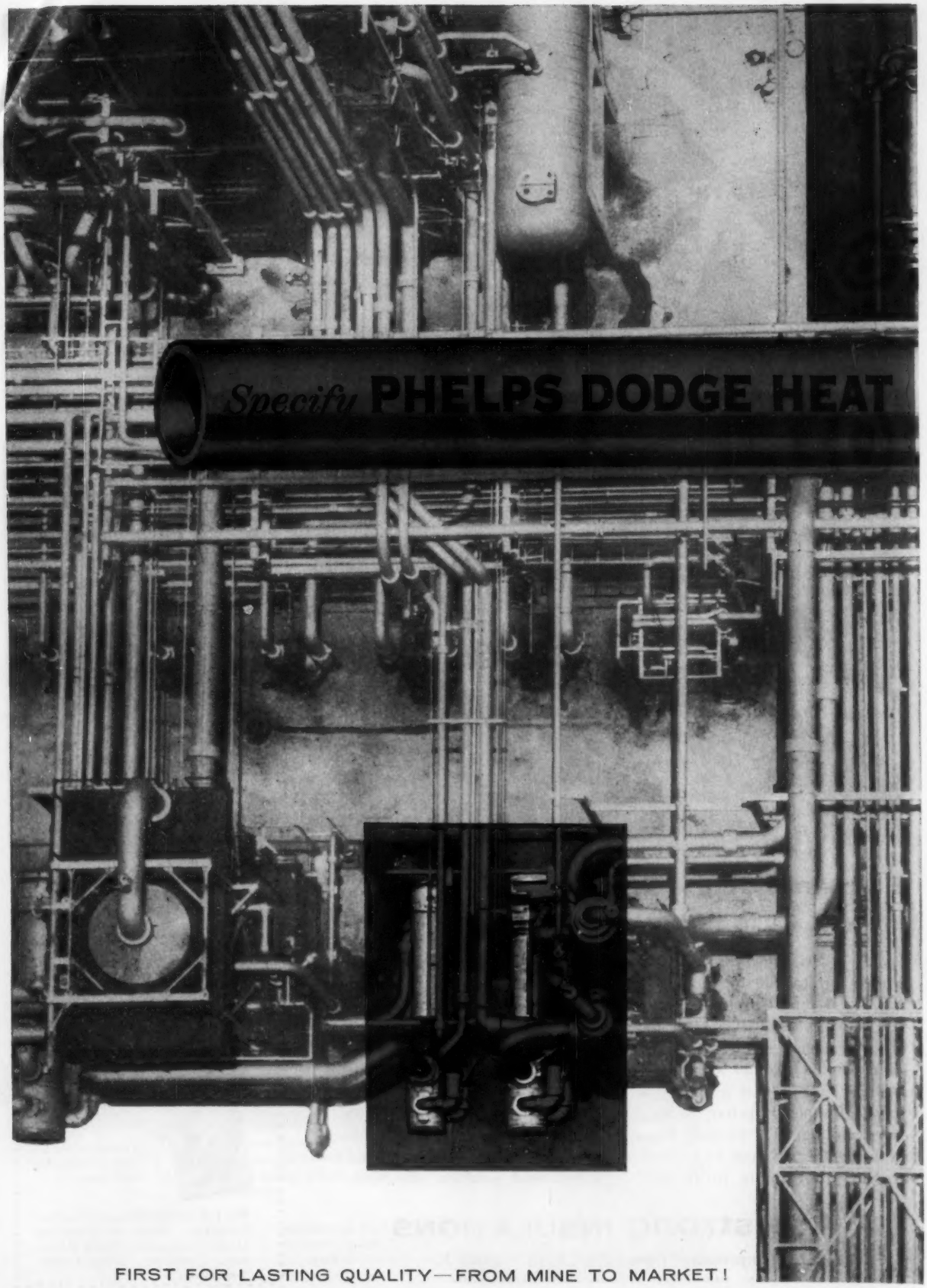
Armstrong Armatemp* Block and Blankets

Armstrong Armaflex®, a Flexible Pipe Insulation

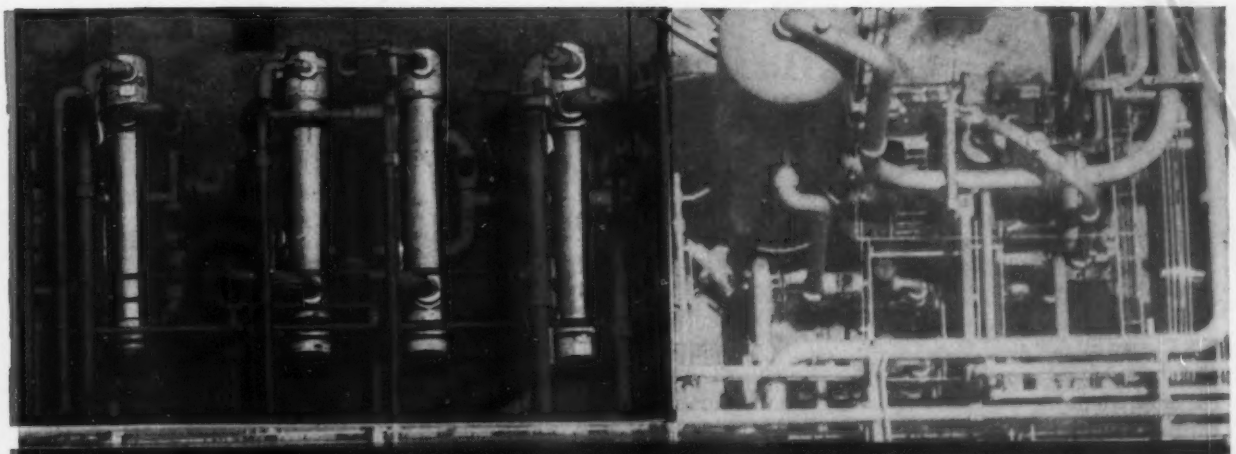
Armstrong LT Cork Covering for Cold Lines

For full information send for free literature. Write to Armstrong Cork Company, 2309 Ream Ave., Lancaster, Pennsylvania.

*TRADE-MARK

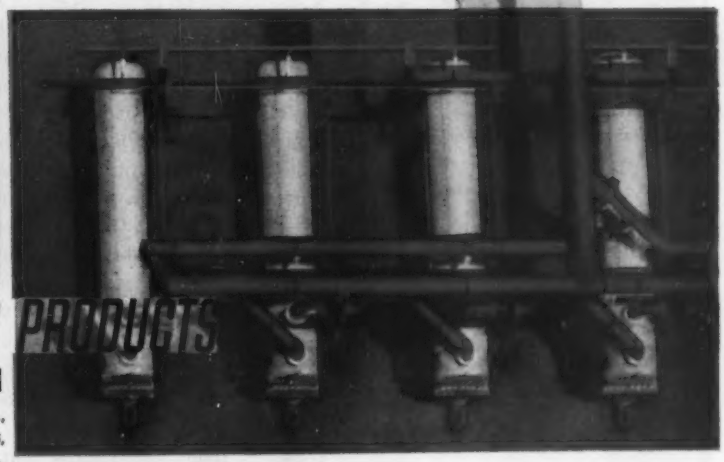


FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!



EXCHANGER TUBES *for Longer Service!*

- Full range of copper-base alloys for every application.
- Vast background of application engineering to assist in proper alloy selection.
- Complete control of quality throughout every step of manufacture.



PHELPS DODGE COPPER PRODUCTS CORPORATION

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For more data on advertised products, use Readers' Service Cards, last page.

An Inside Peek at Steam Trap Capacity Ratings

or . . . how to be sure steam heated equipment is going to work the way it's engineered

WHEN YOU GET all through engineering a steam heated process equipment installation, its performance will depend on whether your steam traps will do what the catalog said.

Now, in theory, if you know the size of a steam trap orifice, you can figure how much water can be pushed through it in a given time by a given steam pressure. But, in practice, this doesn't work out. The picture is scrambled by things like the choking effect of flash steam and restriction of flow through the trap and piping.

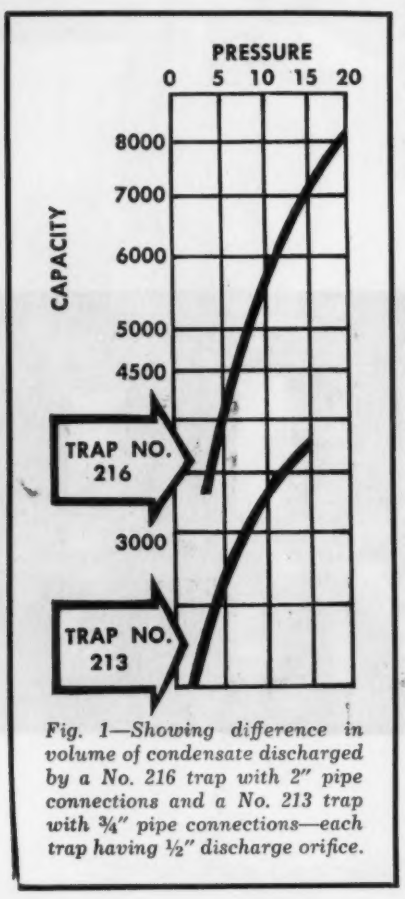


Fig. 1—Showing difference in volume of condensate discharged by a No. 216 trap with 2" pipe connections and a No. 213 trap with ¾" pipe connections—each trap having ½" discharge orifice.

For example, Fig. 1 shows that a ½" orifice in a 125 psi No. 216 Armstrong steam trap with 2" pipe connections will discharge 7200 lb/hr condensate at 15 psi inlet pressure. Yet, a ½" orifice in a 15 psi No. 213 trap with ¾" pipe connections, discharges but 3900 lb/hr at 15 psi inlet pressure. The difference: pipe friction.

Thus, we see a need for investigating the basis for steam trap capacity ratings. Unfortunately, they are not all arrived at in the same way. If they are based on cold water tests, producing no flash steam, they are much too high. Orifice tests are also too high because they ignore pipe friction. Calculations involving flow-through-orifice formulae have never been known to be conservative insofar as traps are concerned.

Armstrong Ratings

Armstrong trap capacity ratings are based on actual operating conditions, determined by hundreds of tests. In these tests condensate at the steam temperature corresponding to test pressure was used. Restriction of flow caused by the choking effect of flash steam, as well as the back pressure created by flash steam and condensate, automatically were taken into account. Actual installation hookups were used, so that pipe friction in both inlet and discharge lines also was reflected in the results.

All this effort assures you the nice, comfortable feeling that comes from knowing a trap will deliver on the job the full capacity claimed in the catalog.

* * *

There is one more ingredient that needs to be tossed into the trap-sizing pot. This morsel is the safety factor—the required excess of trap capacity over calculated condensate load. It will be the subject of the next advertisement in this series. But, in the meantime, if you'd like to get the lowdown, ask for a copy of the 44-page Armstrong Steam Trap Book. It is a complete guide to good trapping practice. It covers not only safety factors, but calculation of condensate loads and trap selection installation, troubleshooting and maintenance. Just call your local Armstrong Factory Representative, or write: **Armstrong Machine Works, 8525 Maple St., Three Rivers, Michigan.**

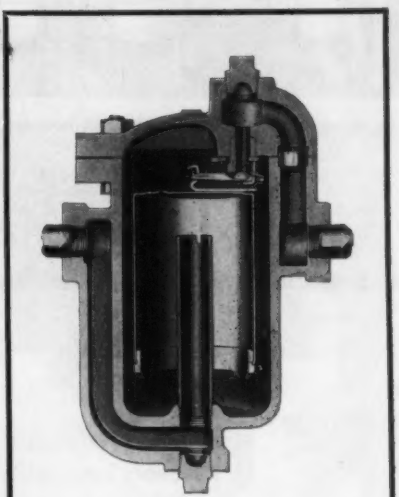


Fig. 2—Armstrong inverted bucket steam trap—hardened chrome steel valve and seat—stainless steel lever and bucket—simple, dependable, long-lived.

ARMSTRONG STEAM TRAPS

BUTANE to BUTADIENE in a single step

HOUDRY DEHYDROGENATION PROCESS

gives one-step process simplicity and flexibility in transforming . . .

BUTANE to BUTADIENE or BUTENES

BUTENES to BUTADIENE • ISOBUTANE to ISOBUTENE

Other light hydrocarbons to mono- and di-olefins

The Synthetic Rubber Industry is growing through expanded butadiene production made available by the Houdry Dehydrogenation Process. Houdry has designed and licensed over 50% of all new U.S. butadiene capacity built since 1946. In the past two years alone over 250,000 annual tons of Houdry butadiene capacity has been licensed. These units are either already in operation or nearing completion.

Over 12 years of commercial performance has firmly established a record of flexibility and economy worth investigating. Write for process literature and application assistance.

PROCESS-PROVED CATALYST

Houdry Chrome-alumina Dehydrogenation Catalyst is the result of fundamental and applied research combined with manufacturing experience. For single step olefin and di-olefin production from paraffins, Houdry Chrome-alumina is unequalled for long-term stability and selectivity.

HOUDRY

PROCESS CORPORATION

1528 Walnut Street, Philadelphia 2, Pa.

PIONEER IN CATALYTIC PROCESSES

You Can Pump in controlled volume

HYDROCHLORIC ACID... all concentrations

CHLORINATED HYDROCARBONS

CORROSIVE METALLIC SALT SOLUTIONS

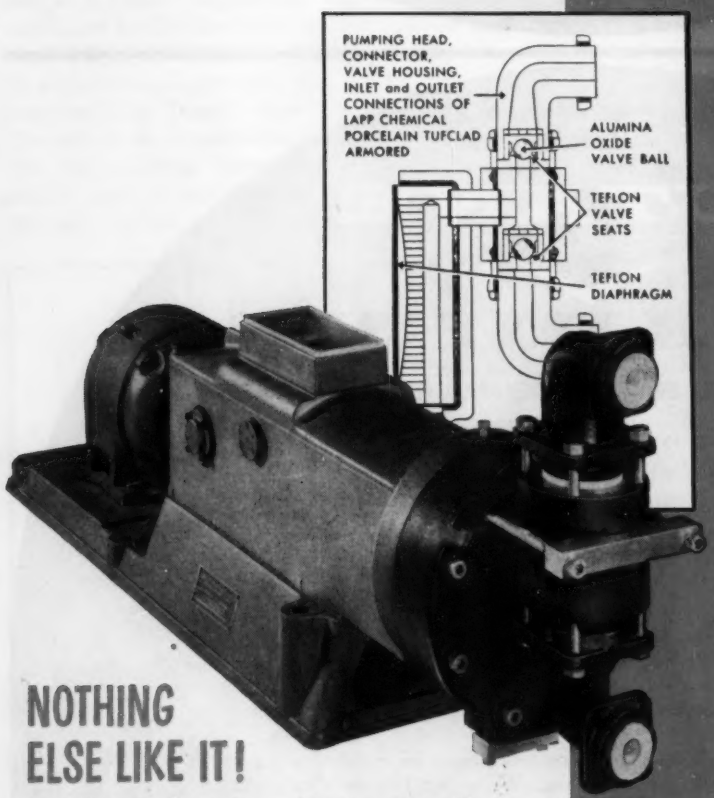
DILUTE ACIDS

MIXED ACIDS

WITH

Lapp PULSAFEEDER

COMPLETELY NON-METALLIC CONSTRUCTION AND NO STUFFING BOX TO LEAK


PUMPING HEAD, CONNECTOR, VALVE HOUSING, INLET and OUTLET CONNECTIONS OF LAPP CHEMICAL PORCELAIN TUFCLAD ARMORED
ALUMINA OXIDE VALVE BALL
TEFLON VALVE SEATS
TEFLON DIAPHRAGM

Solid Lapp Chemical Porcelain, combined with parts of alumina ceramic and Teflon plastic, is used for the liquid end of this model of Lapp Pulsafeeder. All parts which can come in contact with liquid being pumped are non-metallic, chemically inert. Thus, positive-displacement metered pumping of "hard-to-handle" corrosive chemicals is made certain and permanently trouble-free.

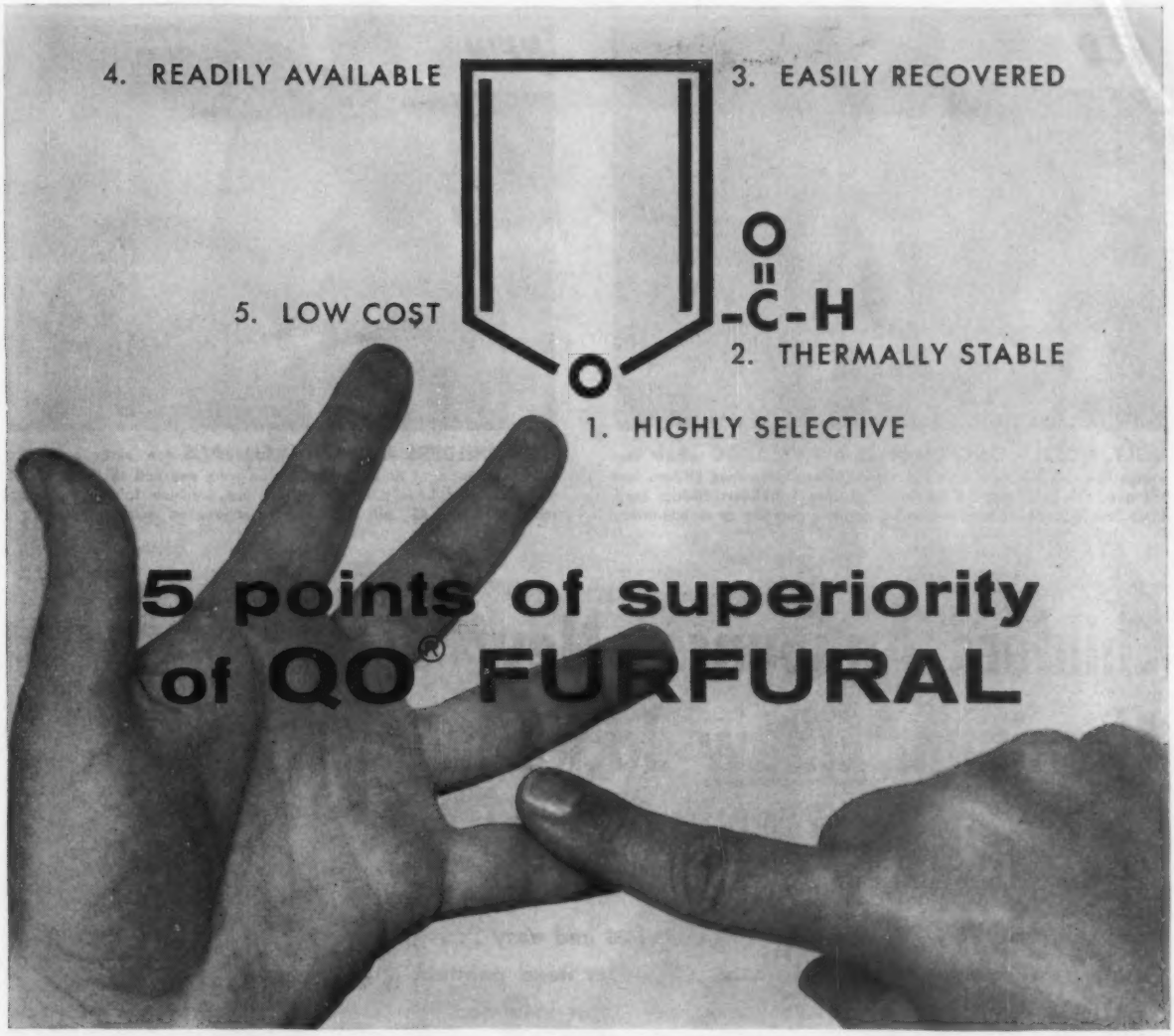
NOTHING ELSE LIKE IT!

Lapp Pulsafeeder is the combination piston-diaphragm pump for controlled-volume pumping of fluids. Reciprocating piston action provides positive displacement. But the piston pumps only an hydraulic medium, working against a diaphragm. A floating, balanced partition, the diaphragm isolates chemical being pumped from working pump parts—eliminates need for stuffing box or running seal. Pumping speed is constant; variable flow results from variation in piston-stroke length—controlled by manual hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

WRITE FOR BULLETIN 440

with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 538 Poplar St., Le Roy, N. Y.

Lapp



1. HIGHLY SELECTIVE:

QO Furfural is highly selective in separating a wide variety of closely related compounds in such operations as refining of lube oil, gas oil, cycle stock, and extractive distillaton of C_4 hydrocarbons.

2. THERMALLY STABLE:

QO Furfural is thermally stable under the conditions of extraction and recovery, thus permitting long continuous plant operation.

3. EASILY RECOVERED:

QO Furfural is easily recovered. Some refiners report less than 0.02% solvent loss of the furfural circulated.

4. READILY AVAILABLE:

QO Furfural is readily available in large quantities from annually renewable raw material sources.

5. LOW COST:

QO Furfural costs only pennies per pound and has an outstanding record of price stability during its 25 year's use by the oil industry.

The Quaker Oats Company

CHEMICALS DEPARTMENT

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Room 540Y, 120 Wall St.,
New York 5, N. Y.

Room440Y, 48 S.E. Hawthorne Blvd.
Portland 14, Oregon

In the United Kingdom:
Imperial Chemical Industries, Ltd., Billingham, England

In Europe:
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Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France;
A/S "Ota", Copenhagen, S. Denmark

In Australia:
Swift & Company, Ltd., Sydney

In Japan:
F. Kanematsu & Company, Ltd., Tokyo

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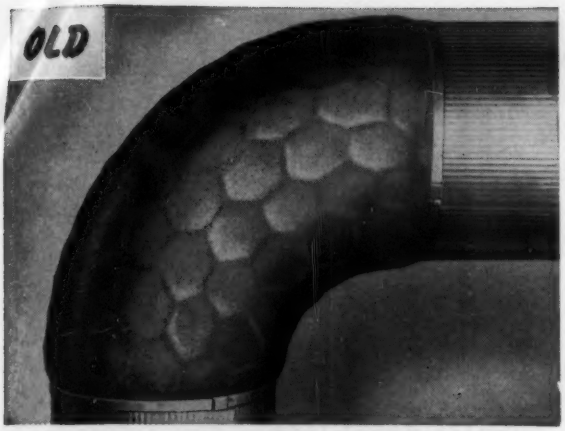
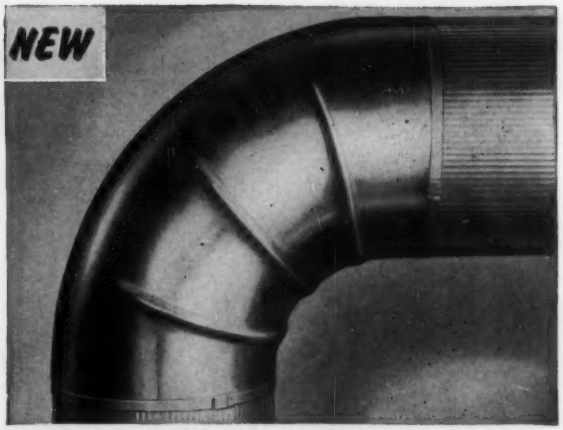


UGLY, COSTLY CHICKEN WIRE AND MASTIC elbow coverings like this are now obsolete. New Childers Aluminum Ell-Jacs end the need for slow, costly hand-made "patches". Childers Ell-Jacs keep their new look, never need expensive periodic painting or maintenance.



NEW CHILDERS ALUMINUM ELL-JACS now make possible neat, weather-tight aluminum protection from one end to the other of your insulated lines. Childers Ell-Jacs are precision formed for long-radius 90° and 45° ells and have factory-applied moisture barrier.

Childers Announces New Aluminum Elbow Jacketing For Insulated Lines

Revolutionary new Childers Ell-Jacs go on fast and easy . . . fit perfectly . . . cut installation costs . . . never need painting . . . and, used with Childers Jacketing, give your insulated lines that well-dressed look from end to end.

Now, aluminum elbows are made in a wide range of sizes by America's leading manufacturer of aluminum jacketing. Childers Aluminum Ell-Jacs are available for quick, easy application to protect costly elbow insulation.

Childers Ell-Jacs, together with Childers Jacketing, enable you to install maintenance-free aluminum over every square foot of your valuable insulation. You protect *all* of your insulation investment at lowest cost. You get the bonus of a better looking plant and easier housekeeping. Aluminum *keeps* its new look, needs no expensive periodic painting.

Positive weather-proofing, too, is assured by exclusive Childers Lap-Seal (Patents Pending). Factory-attached moisture barrier prevents harm to the underneath side of the aluminum.

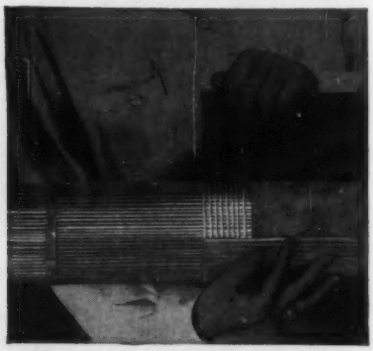
First cost is less for Childers Jacketing than for any other permanent type weatherproofing—even less than some temporary coverings.

You also get greater strength and greater protection because Childers Jacketing is cross-crimped.

It's easy to install Childers Jacketing. All you need are pliers and screwdriver, plus inexpensive strapping. Two men can do the job. Jacketing can be removed for inspection of the lines, then reapplied without waste.

Why not benefit from Childers world-wide experience when you buy insulation for your lines, towers, vessels, and tanks? More than 2,000 petroleum refining, petro-chemical, and chemical plants will endorse your decision. Childers Engineering Representatives, located in 27 major industrial centers, give professional advice on insulation jacketing.

For a free sample of Childers Aluminum Weather-Proof Jacketing, with engineering data on how to safeguard your insulation, write Childers Manufacturing Company, Dept. PR-39, P. O. Box 7467, Houston 8, Texas.

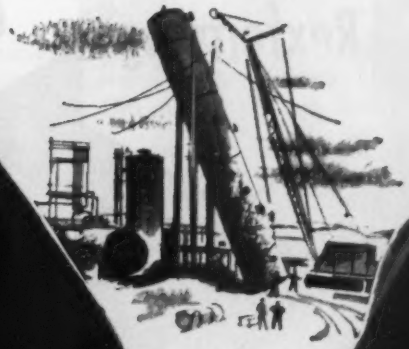


EXCLUSIVE LAP-SEAL, available at no extra cost, is a series of 8 ribs rolled into the underlapping edge of the jacketing, providing automatic measure of the 2" circumferential lap. Proper lap is assured without waste. Labor is saved. Where desired, a positive weather seal is easily made with Lap-Seal and a mastic.

DEEP CORRUGATED Childers Jacketing in 1¼" and 2½" corrugations is recommended for permanent protection and improved appearance of insulated towers, vessels, tanks. Deep Corrugated Jacketing with factory-attached moisture barrier is another product available only from Childers.

See Childers' ad in Sweet's Industrial Construction File, Chemical Engineering Catalog and Refinery Catalog.

When you plan process plant facilities, take advantage of Girdler's proven experience as engineer-constructors



The **GIRDLER** Company

A division of National Cylinder Gas Company
LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION . . . Design, Engineering, Construction of Hydrocarbon Processing Plants, Gas Producing Plants, Chemical Plants. High grade specialty Catalysts.

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Celanese Corp. of America
Chemstrand Corp.
Cities Service Oil Co.
Colgate-Palmolive Co.
Consumers Farm Chemicals Assn.
Delta Refining Co.
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E. I. duPont de Nemours & Co.
Eastman Kodak Co.
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Goodrich-Gulf Chemicals, Inc.
Hercules Powder Co., Inc.
Lever Bros. Co.
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Rohm & Haas Co.
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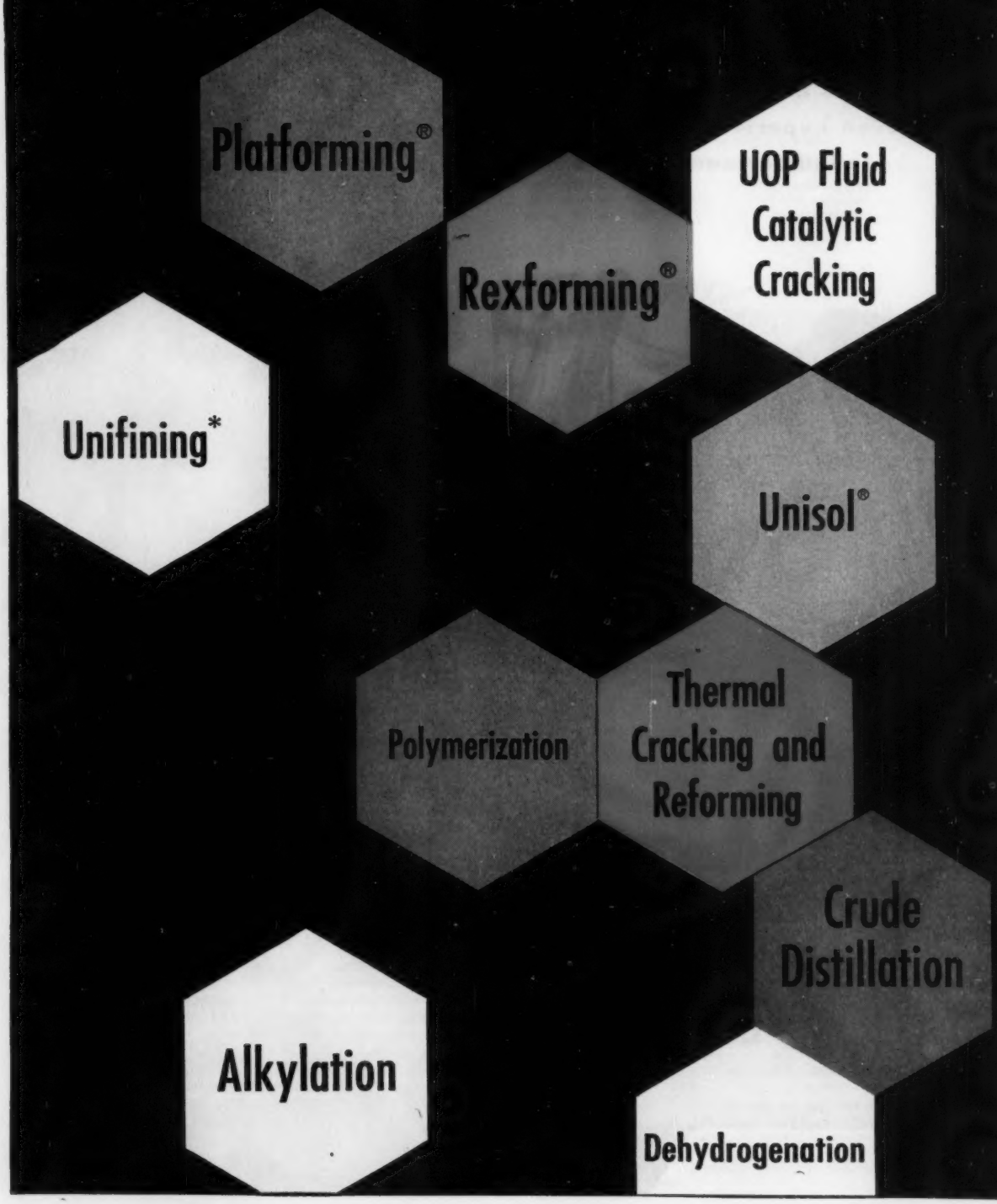
Southern Nitrogen Co., Inc.
Standard Oil Co. of Calif.
Standard Oil Co. (Indiana)
Standard Oil Co. of Louisiana
Sun Oil Co.
Swift & Co.
Tennessee Eastman Co.
Texas Eastman Co.
Union Oil Co. of California
Wilson & Co., Inc.

What we can do for YOU is described in new brochure G-306. Write for your copy today.

15 important UOP processes to serve



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Visbreaking

the oil refining business

Udex®

Penex*

Wherever you go, the world over, you'll find these UOP processes helping refiners do a better job.

The names displayed here identify some of the most widely used and best known refining and petrochemical processes made available to the entire petroleum industry by Universal Oil Products Company.

But mere process names and techniques do not indicate the full measure of their importance to the industry. What really counts is the ability to adapt the right processes to each individual refiner's needs.

UOP is not just in the business of developing and licensing refining processes. That's only the beginning. The big part of our job is helping the individual refiner make use of our modern developments to better his operating and economic position by producing a larger volume of high quality products from every barrel of crude he processes.

That's why UOP refining and petrochemical processes are highly flexible in design, in through-put, in product, tailored to the individual refiner's needs. That's why UOP carefully analyzes the economics of any process in relation to individual product and market requirements.

For more than forty years UOP has followed the policy of making sure that its developments are applicable, economically and practically, to their user's needs. Whatever the processing needs Universal will continue to serve the oil refining business well.

UOP®

UNIVERSAL OIL PRODUCTS COMPANY

30 Algonquin Road, Des Plaines, Illinois, U.S.A.

More Than Forty Years Of Leadership In Petroleum Refining Technology

*Trademark

Low Pressure Coking

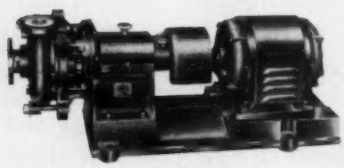
Catalytic Condensation

For more data on advertised products, use Readers' Service Cards, last page.

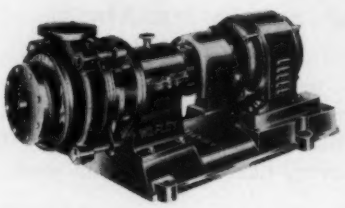
WILFLEY ACID PUMPS

LOW COST PUMPING

of Acids, Corrosives, Hot Liquids & Mild Abrasives



The new WILFLEY MODEL "AF" acid pump is famous for efficiency and dependability. Actual production-line records show worthwhile dollar savings in stepped-up performance and low-cost operation. Every day, in modern chemical plants the world over, WILFLEY Acid Pumps move hard-to-handle solutions on a trouble-free, round-the-clock schedule. Available in 5 to 3,000 GPM capacities with heads from 15 to 200′ and higher.



WILFLEY "AF" PACKINGLESS Acid Pump is available with wetted pump parts of any machinable alloy as well as plastics. This versatility of materials, as well as rugged heavy-duty construction and sound mechanical design, combine with the unique WILFLEY principles to make this an ideal pump for any corrosive service.

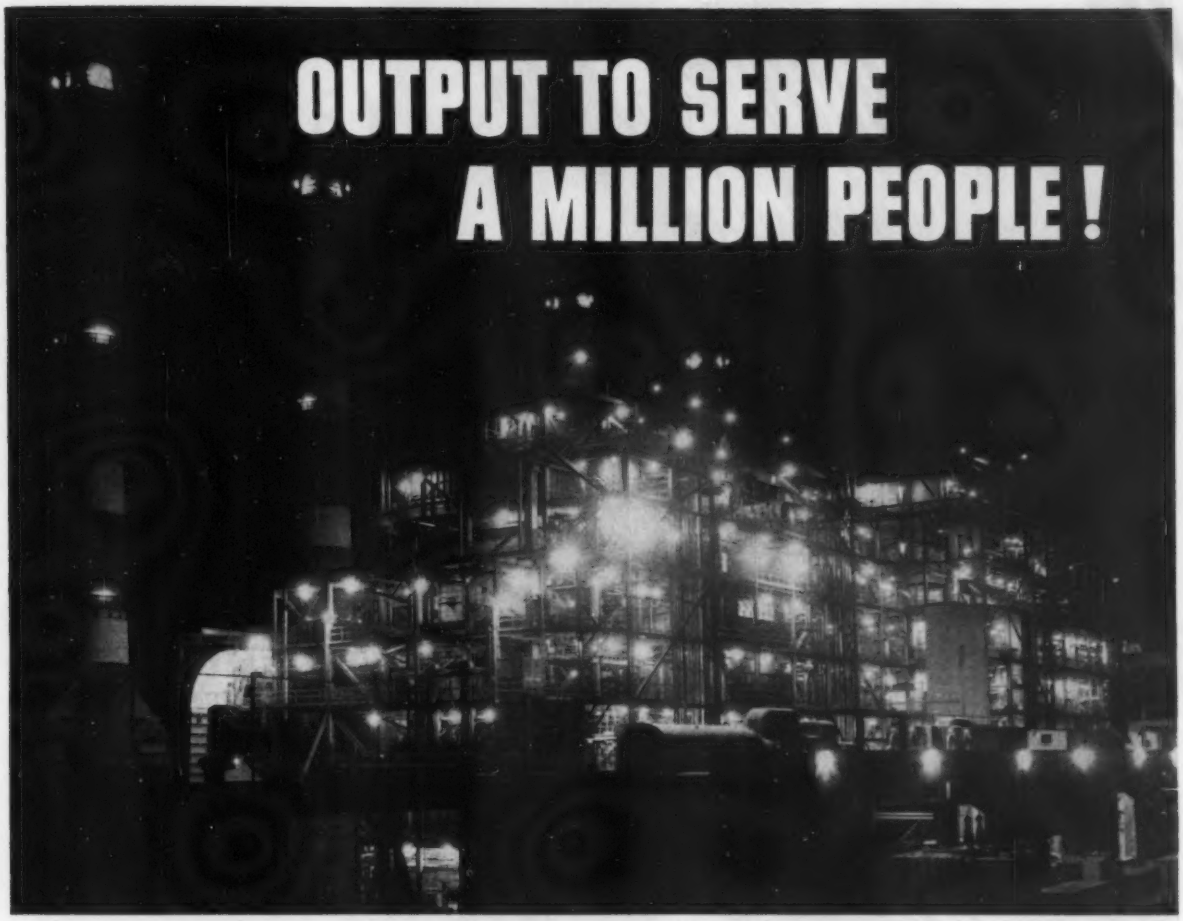
INDIVIDUAL ENGINEERING ON EVERY APPLICATION

A. R. WILFLEY and SONS, INC.

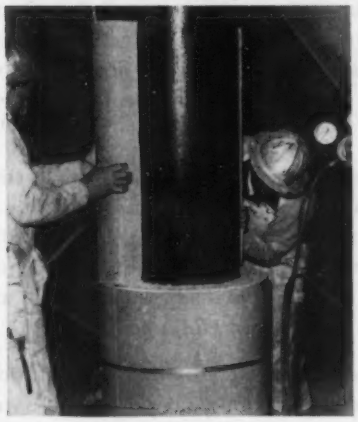
DENVER, COLO., U.S.A.—NEW YORK OFFICE: 122 E. 42ND ST., NEW YORK CITY 17

Willey Sand Pumps
"Companions in Economical Operation"
Willey Acid Pumps

OUTPUT TO SERVE A MILLION PEOPLE!



from closed-circuit television to **UNIBESTOS®** *pipe insulation . . . one of the West's most modern*



Single-layer **UNIBESTOS** locks in more heat than most double-layer insulations. It resists shock, vibration, and chemical fumes—doesn't shrink to expose pipe to heat loss. Sizes to 44" o.d. Ask for UNARCO'S free 40-page booklet with exclusive "J" Factor Tables.

This is the new $80,000,000.00 Valley Steam Plant of the Los Angeles Department of Water and Power, latest addition to municipal steam electric generating faciiities which, today, supply more than three-quarters of the city's electricity requirements. In 1941, 95% came from hydroelectric sources.

Valley Steam Plant is big and efficient, with a generating capacity of 512,000 kilowatts. It has about 1700 control switches, instruments, and relays; 761 miles of control wire and power cable; 605 electric motors ranging in size up to 2250 h.p. and – of course – UNIBESTOS® Pipe Insulation throughout, aluminum-jacketed where exposed to the elements.

Closed-circuit television, with six screens in each control room, keep watchful eyes on flames and water levels. Automation is a progressive reality here. And modern UNIBESTOS, on piping from 140 to 1000°F., gives further proof of the careful planning that went into this outstanding project.

UNIBESTOS also is used by the Los Angeles Department of Water and Power at the Harbor Steam Plant, by major power plants the country over . . . by petroleum and chemical processors, atomic developments, and modern industry for dependable conservation of energy.

UNARCO®

UNION ASBESTOS & RUBBER COMPANY

1111 West Perry Street, Bloomington, Illinois

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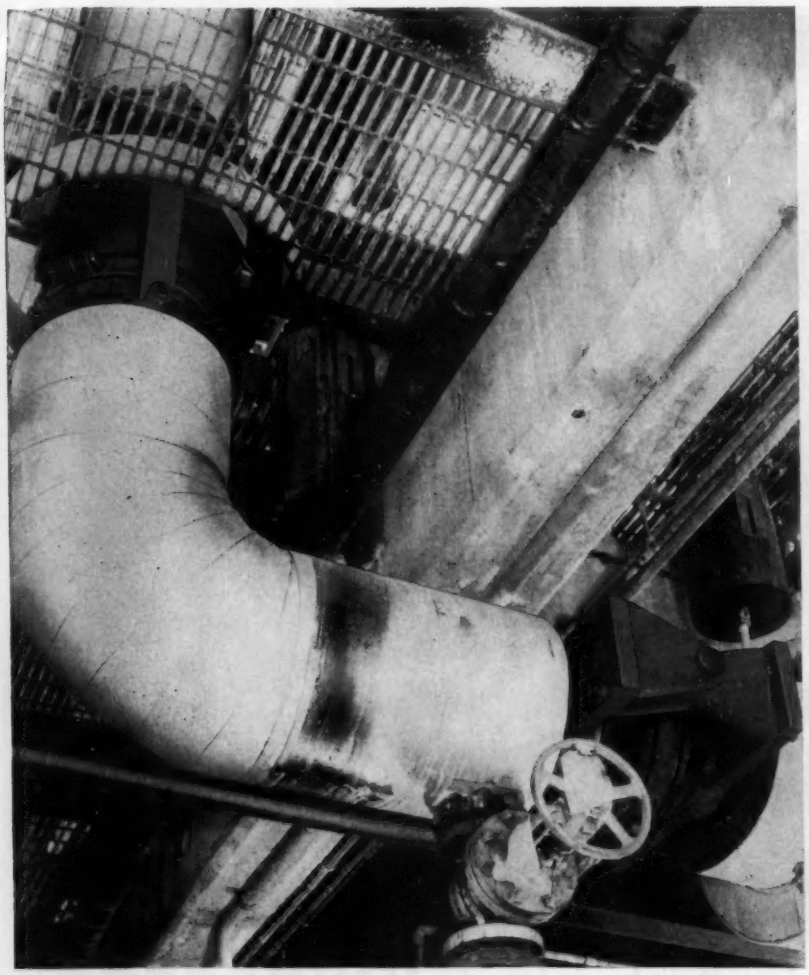


THIS IS WHAT

ADSCO

MEANS BY

SPECIAL

JOINTS

The photo shows a small but very important section of an insulated, spring-suspended 8″ pipe line in the new Moundsville, W. Va., plant of the National Aniline Division of Allied Chemical & Dye Corp. At the point shown, the line is subjected to complex stresses which are completely resolved and placed in balance by the ADSCO Gimbal Expansion Joint, upper left, and the ADSCO Hinge Expansion Joint, lower right.

In the Gimbal Joint, two sets of bars are pinned to the octagonal ring at 90° to each other. The other ends of the bars, still at 90° to each other, are pinned to the pipe leading into the joint. Running through the center of the ring, with a slight clearance, is a nipple connecting two expansion elements. This gimbal arrangement permits the joint to absorb 6° of angular movement from two different directions: the left and right motion of the horizontal part of the ell and similar motion from other unseen upper horizontal piping at 90° to the plane of the lower piping.

A partner to the Gimbal Joint and an indispensable part of this piping system is the Hinge Joint shown lower right. This absorbs the angular rotation of the ell caused by the expansion and contraction of the vertical piping.

There are so many motions involved in this section that, under certain conditions, the octagonal ring of the Gimbal Joint could describe a circle. Yet ADSCO and National Aniline engineers were able to identify all the motions and absorb them economically and efficiently by the Gimbal and Hinge Joints.

ADSCO designs and manufactures many types of both standard and special joints for many purposes. Consult ADSCO on any piping problem.

ADSCO DIVISION

YUBA CONSOLIDATED INDUSTRIES, INC.

20 MILBURN ST. BUFFALO 12, N. Y.

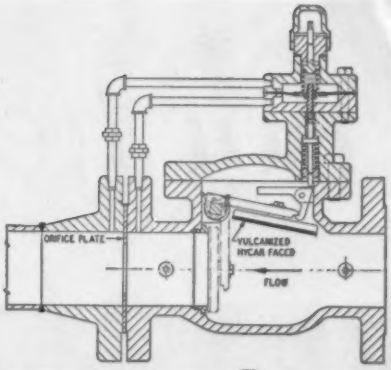
COPPUS SENTRY® VALVES

Stop flow instantly or Start flow instantly Automatically

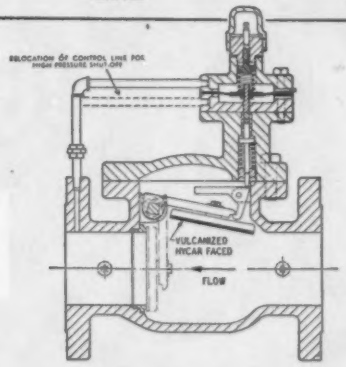
And when they flow, it's full flow

ANOTHER
COPPUS
"BLUE RIBBON" PRODUCT

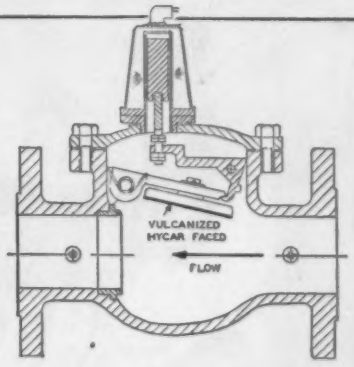
MODEL 1200 SENTRY EXCESS FLOW SHUT-OFF VALVE — shuts off gas or liquid instantly when flow exceeds predetermined rate.

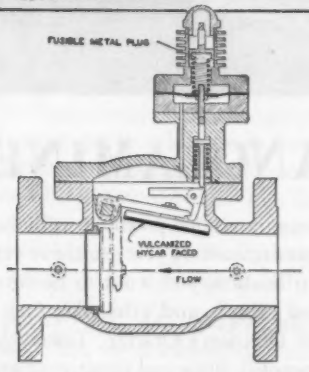


MODEL 1500H SENTRY HIGH PRESSURE AND MODEL 1500L LOW PRESSURE SHUT-OFF VALVES — shut off gas or liquid instantly when predetermined pressure limits are reached.

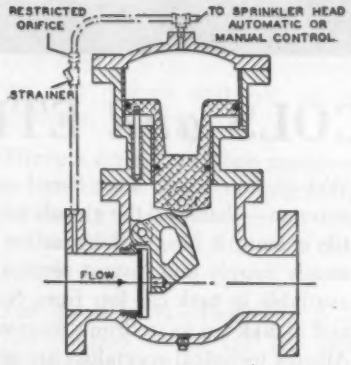


MODELS 1700 AND 1800 SENTRY SOLENOID SHUT-OFF VALVES — shut off gas or liquid instantly by remote electrical control.





MODEL 2200 SENTRY OVERPRESSURE AND OVERTEMPERATURE SHUT-OFF VALVE — shuts off gas or liquid instantly in case of excessive pressure or ambient temperature.



MODEL 3000 SENTRY PISTON OPERATED QUICK-OPENING VALVE — starts gas or liquid flow instantly when pressure in piston chamber is released. Ideal for deluge system and for automatic opening and closing by instrument-air or electrical control.

COPPUS ENGINEERING CORP.
422 PARK AVENUE
WORCESTER 10, MASS.

Please send information on Sentry Valve model 1200 ☐, 1500H and 1500L ☐ 1700 and 1800 ☐, 2200 ☐, 3000 ☐.

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Address.....

City.....

State.....

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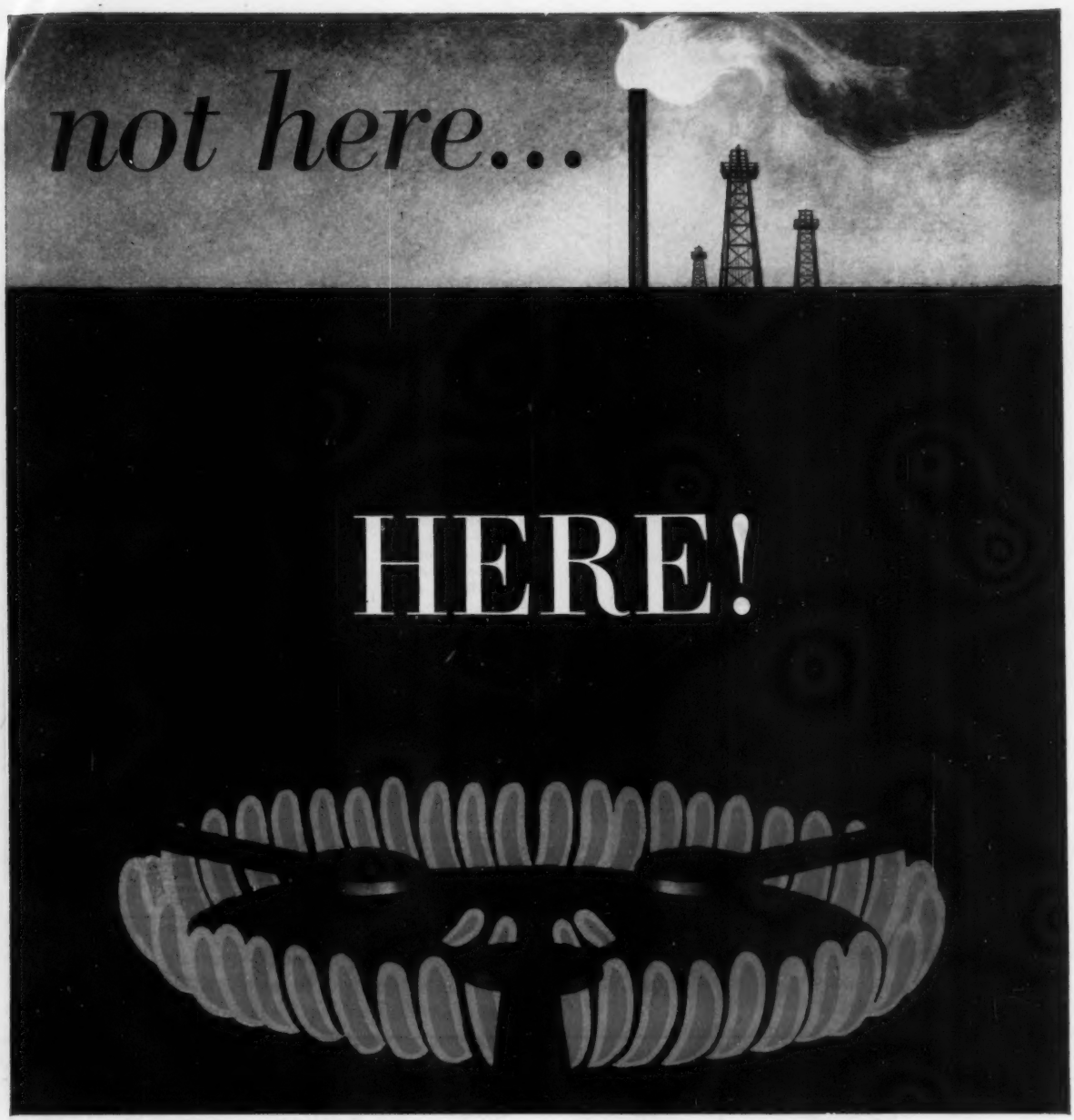

because of GLYCOLS *and* ETHANOLAMINES

Wet or sour gases, once flared as a nuisance, now produce millions in revenue — thanks to the glycols and ethanolamines. If you use these versatile chemicals for gas dehydration or purification, you want to be sure of steady supply and instant service. Allied glycols and ethanolamines are available in tank car lots from Nitrogen Division's Orange, Texas plant, and in tank trucks or drums from warehouses in principal producing areas. Allied's technical specialists are always on call to help with any application problems you may have.

Dept. GA 1-21-4

Allied Chemical — Nitrogen Division

40 Rector Street, New York 6, N. Y.

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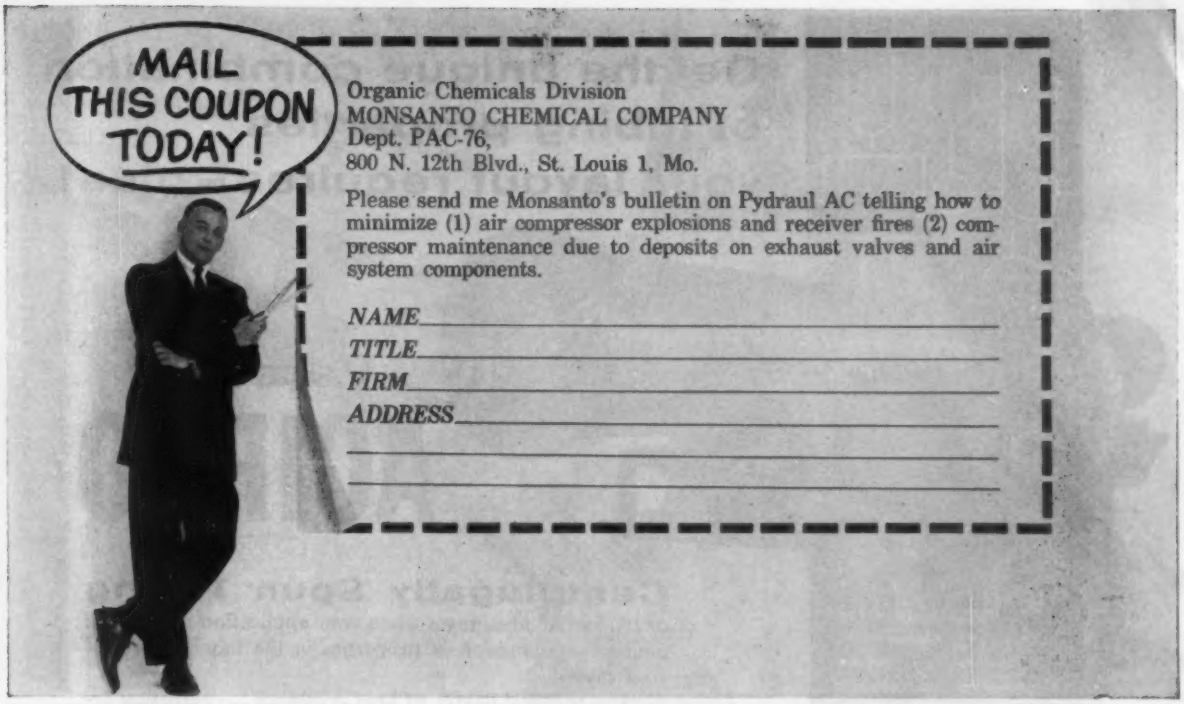
MAIL THIS COUPON TODAY!
Organic Chemicals Division
MONSANTO CHEMICAL COMPANY
Dept. PAC-76,
800 N. 12th Blvd., St. Louis 1, Mo.
Please send me Monsanto's bulletin on Pydraul AC telling how to minimize (1) air compressor explosions and receiver fires (2) compressor maintenance due to deposits on exhaust valves and air system components.
NAME
TITLE
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ADDRESS

Want to reduce fire hazard in your air compressors?... Read Monsanto's bulletin on Pydraul AC

When flammable oil mists and films gather in your compressed air system . . . you have a real fire risk!

Ease your mind—there's a new, fire-resistant lubricant to protect your equipment, your workers and your production flow from compressor fires and explosions caused by flammable oils. Simply replace your ordinary petroleum oils with fire-resistant Pydraul AC compressor lubricant.

Pydraul AC is chemically made, not a water-soap base mixture, not a petroleum oil. It's a completely new type of bearing-protecting lubricant. Pydraul AC is created especially for air compressors. With Pydraul AC lubrication you ease your mind about compressor fires and explosions. You may also reduce maintenance costs because Pydraul AC can minimize carbon deposits on air compressor exhaust valves and air piping systems.

There's no conversion problem—just drain out the flammable lubricant and replace with fire-resistant Pydraul AC—it's that easy!

For more facts—fast: Just mail the coupon today for the new Monsanto bulletin on Pydraul AC. No cost to you. It shows properties, field experience, operating economies, etc. Act *now.* Mail coupon *today!*

There's also a fire-resistant Pydraul for every industrial hydraulic job:

- General-purpose Pydraul F-9
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Organic Chemicals Division
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MONSANTO®

Where Creative Chemistry Works Wonders For You

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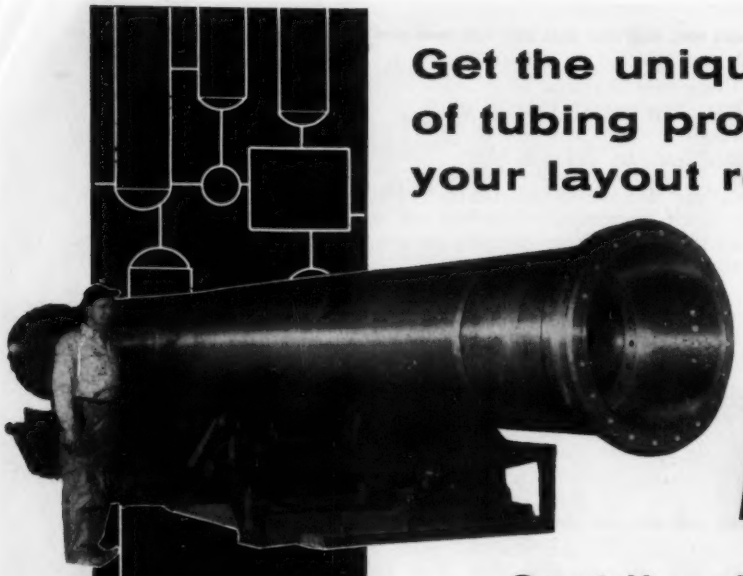
Get the unique combination of tubing properties your layout requires—plus!



Type 310 stainless steel retort (25% Chrome—20% Nickel) fabricated and machined at Acipco. Completed retort is 27'-6" long and weighs 12,500 pounds.

Versatile ACIPCO

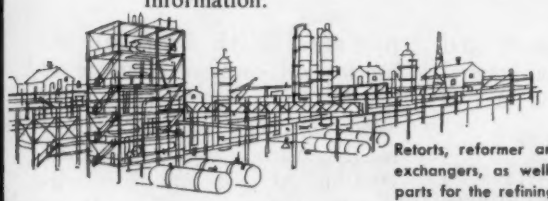
Centrifugally Spun Tubing

offers special advantages when your application requires an unusual combination of properties in the tubular parts of your layout.

Any required degree of heat resistance . . . corrosion resistance . . . abrasion resistance . . . strength — or any combination of physical, chemical or metallurgical properties — can be produced in special steel or alloy iron analyses at ACIPCO.

"Custom spun" in a wide range of ID's and OD's, ACIPCO tubes can be furnished as cast, rough or finished machined, or *completely fabricated* to your exact specifications in large or small quantities.

Investigate the plus advantages of ACIPCO's "one-source — from tube to finished part" service. Call or write the ACIPCO distributor nearest you, or write direct, for full information.



Retorts, reformer and furnace tubes, heat exchangers, as well as hundreds of other parts for the refining and petrochemical industries have been fabricated from Acipco centrifugally spun steel and alloy iron tubes.

SIZE RANGE: Lengths up to 410" to meet modern requirements have been produced. OD's from 2.25" to 50"; wall thicknesses from .25" to 4".
ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels; plain carbon grades and special non-standard analyses.
FURNISHED: As cast, rough machined, or finish machined, including honing.

DISTRIBUTORS

Austin-Hastings Co., Inc.
226 Binney Street
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J. M. Tull Metal & Supply Co.
285 Marietta St., N.W.
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Star performers in any installation...

CHASE® HEAT EXCHANGER TUBES

Chase Antimonial Admiralty Heat Exchanger Tubes lead the way in outstanding performance...length of service. Here's why: Careful alloying, with the proper amount of antimony, all but eliminates dezincification failures. Grain structure is unaffected! The tube stays strong...tough enough to withstand wearing stress and strain. You benefit through longer, more efficient on-the-job service. Learn how Chase can play an important role in your specific installation. Write for your free 54-page manual: *"Chase Condenser and Heat Exchanger Tubes."*

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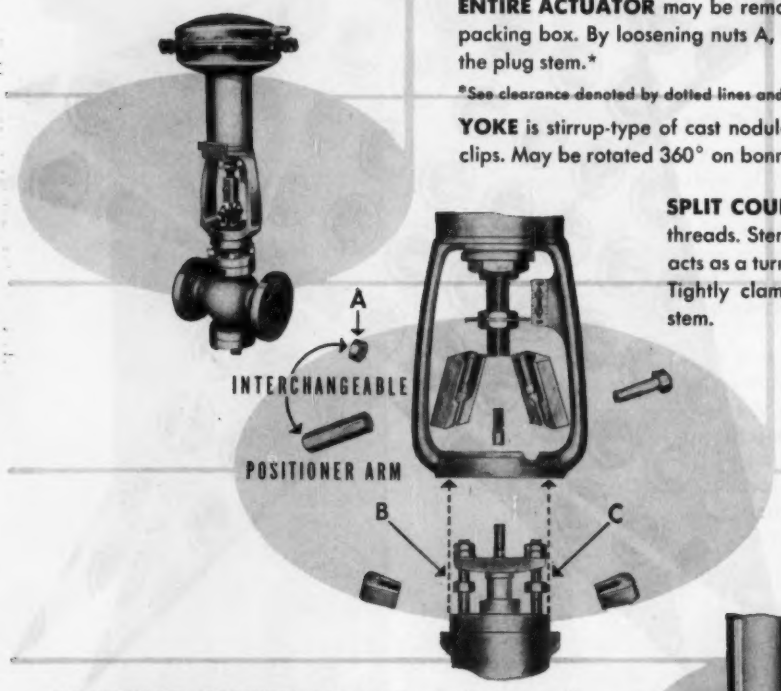
Simplicity...

KEYNOTE

OF THE NEW H-D ACTUATOR



ENTIRE ACTUATOR may be removed and replaced without disturbing the packing box. By loosening nuts A, B, and C the actuator may be lifted over the plug stem.*

*See clearance denoted by dotted lines and arrows.

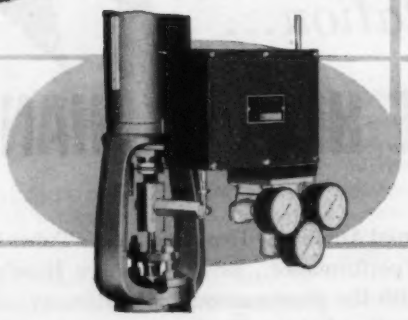
YOKE is stirrup-type of cast nodular iron. Held to bonnet by stainless steel clips. May be rotated 360° on bonnet.

SPLIT COUPLING has L.H. (upper) and R.H. (lower) threads. Stems do not engage—do not meet. Coupling acts as a turnbuckle for adjusting plug seating tension. Tightly clamped coupling prevents twisting of plug stem.

SLOTTED HOLDING CLIPS permit removal of clips without removing nuts B and C.

SPRINGS are available in three interchangeable ranges, 3-15, 5-25, and 6-30 psi. Interchangeable in any actuator — no additional parts required.

POSITIONER BRACKET (Universal) supplied on all valves for the mounting of any positioner. No valve disassembly required — Positioner can be mounted in the field by removing nut A and replacing it with the positioner arm.



HAMMEL-DAHL COMPANY

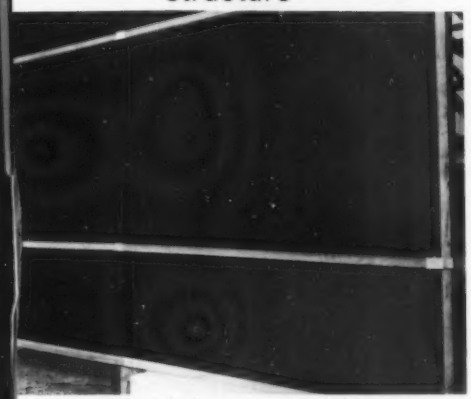
WARWICK INDUSTRIAL PARK, PROVIDENCE 5, R. I., U. S. A.

SALES OFFICES IN ALL PRINCIPAL CITIES

MANUFACTURERS ABROAD: GUELPH ENGINEERING CO., LTD., GUELPH, ONT., CANADA

J. BLAKEBOROUGH AND SONS, LTD., BRIGHOUSE, YORKS, ENGLAND; TERMOKIMIK CORP., MILAN, ITALY

structure

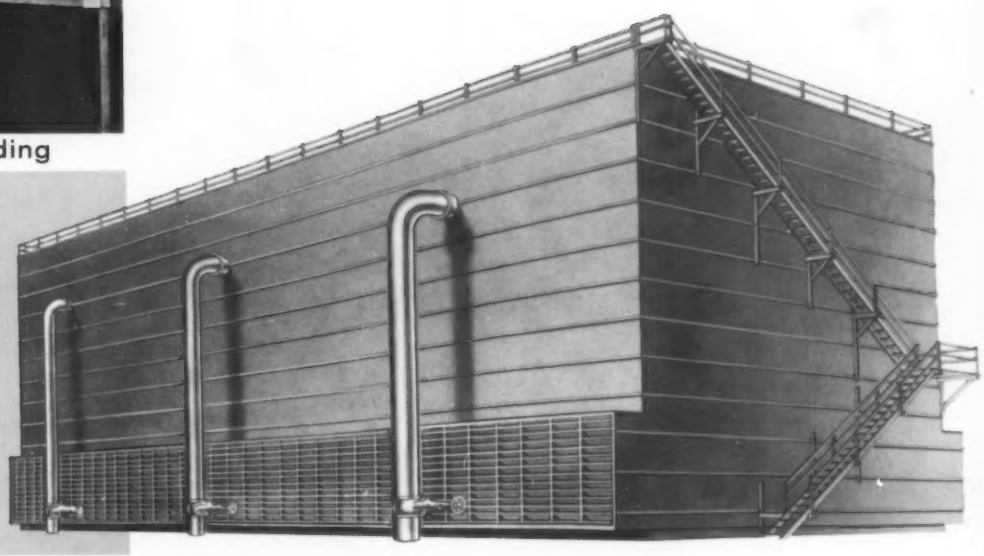


sandwich-panel siding

fan drives

filling

Leadership in Design



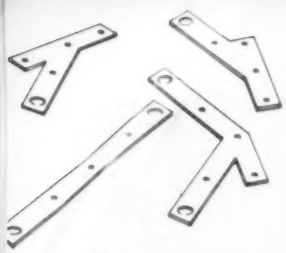
GALLOWAY COUNTER-FLOW COOLING TOWERS

A sixteen page Cooling Tower Brochure will be sent on request.

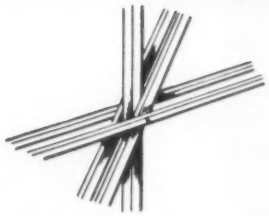
G. W. GALLOWAY COMPANY

Cooling Tower Division

ARCADIA, CALIFORNIA

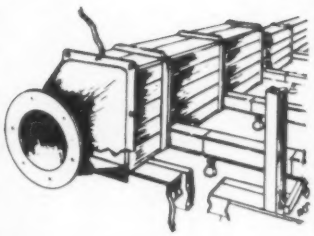


STAINLESS STEEL HARDWARE is recommended as it offers highest corrosion resistance. And since the "straddle bracing system" requires a minimum of bolts and connectors Galloway can offer a cooling tower with stainless-steel hardware at a cost competitive with towers fitted with brass hardware. (Brass and galvanized steel also available.)

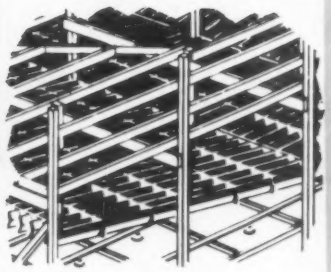


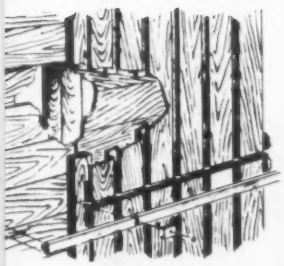
THE "STRADDLE BRACING SYSTEM" used by Galloway in the structural framing offers distinct advantages. Braces straddle the vertical columns and therefore do not require castings or connectors at each column intersection. This saves hardware—and strength of the member is retained by elimination of the connector.

WATER IS DISTRIBUTED through a square central wooden header within each cell. Laterals tie into the header and are equipped with porcelain and stainless steel nozzles. Entire distribution system is easily accessible due to the improved location of drift eliminators. A removable plug permits flushing each lateral.



DRIFT ELIMINATOR is of two-pass sloping design across entire tower. This assures drift losses less than the industry standard of 0.2%. Sloping the eliminator towards the cell center allows higher air exhaust velocities, or less drift loss at normal velocities, and affords adequate access to fan space or distribution system.

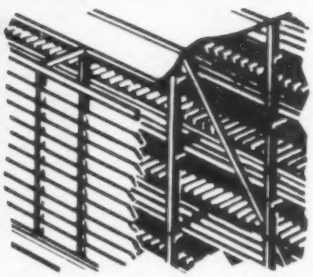




LEAK-PROOF EXTERIOR SHEATHING is one of Galloway's most important contributions to improved cooling tower deign. Standard sheathing designs are a "sandwich panel" which is heavy plywood bonded between two sheets of plastic, a triple wall ventilated wood panel and a corrugated transite. Any of these panel designs are guaranteed not to show leaks.

The G. W. Galloway Cooling Tower Division can combine know-how and facilities with its Engineering and Construction Divisions to offer complete turnkey cooling-tower installations — cooling towers, basins, pumps and piping, and electrical wiring.

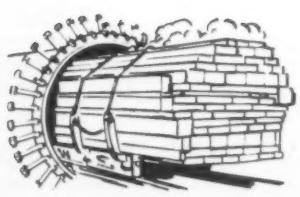
LOUVER INTAKES have been extended a full three feet from the tower face. This assures a neat exterior appearance free of water spray and winter ice. Vertical louver posts placed on three-foot centers support the louvers so as to prevent warping. Louvers are removable to permit access to the tower basin.



A CHOICE OF FAN-DRIVE UNITS is offered: (1) Westinghouse vertical gear-motor, developed especially for cooling tower service, offers the advantages of direct drive, yet eliminates oil leaks and moisture problems; (2) also available is an improved right angle gear unit with floating shaft driven by a standard horizontal motor mounted outside of the fan ring.

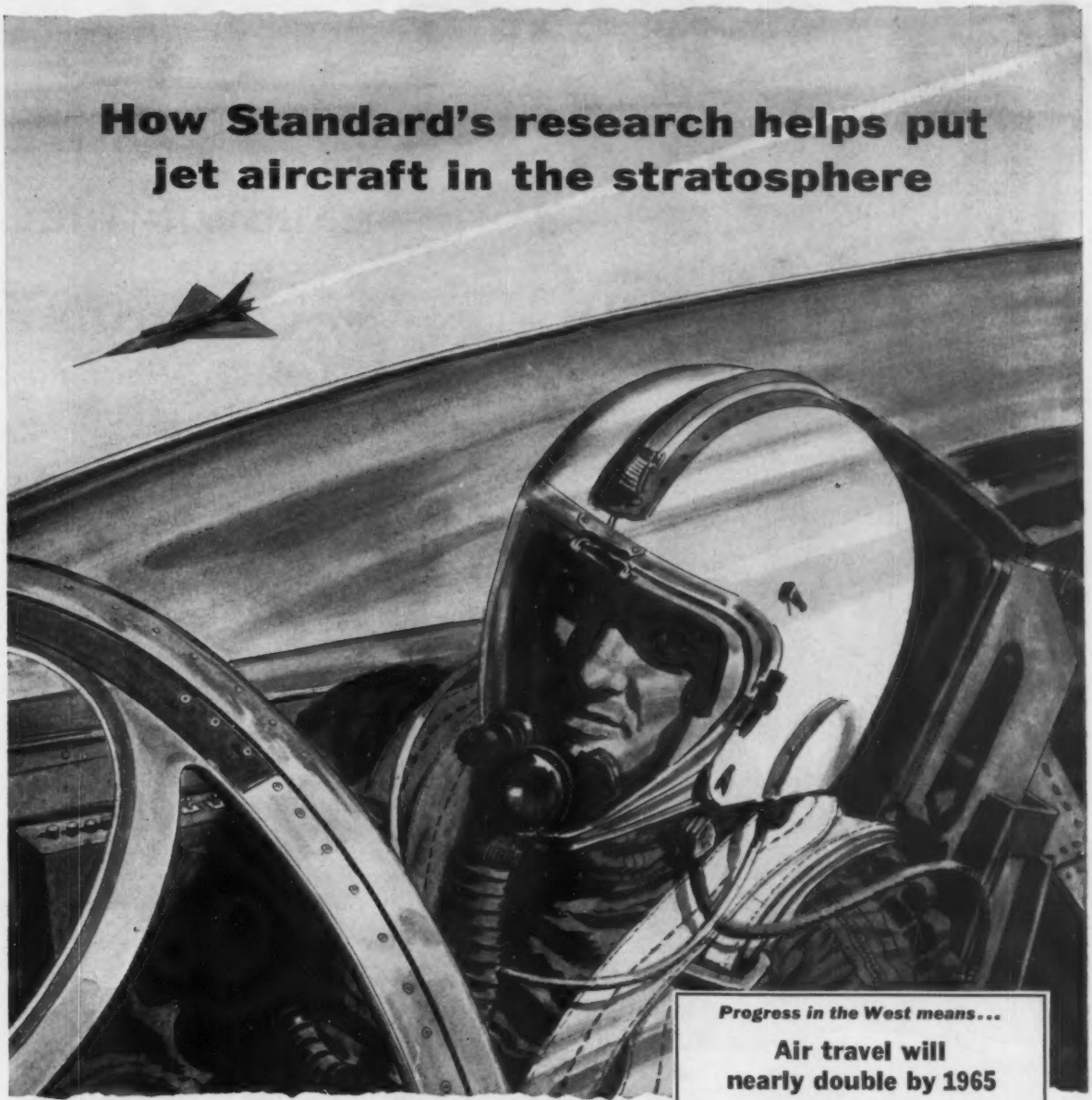
- ● **Lars Anderson Company** — South Weymouth, Massachusetts
- ● **L. A. Christopher Company** — Denver, Colorado
- ● **Fluidpower Company** — Chicago, Illinois
- ● **D. D. Foster Company** — Pittsburgh, Pennsylvania
- ■ **Douglas Fir Mill** — Eugene, Oregon
- ■ **Redwood Mill** — Los Angeles, California
- ● **James S. Kone and Company** — Amarillo, Texas
- ● **Leo P. McCurnin & Son** — New Orleans, Louisiana
- ● **L. D. McKay & Company** — Tulsa, Oklahoma
- ● **The Tennant Company** — Houston, Texas
- ● **Malcolm W. Black & Co., Inc.** — New York City, New York
- ★ **G. W. Galloway Co.** — Arcadia, California

CHOICE OF STRUCTURAL MATERIALS—Chemonite treated Douglas Fir is recommended by the Galloway Company as being a superior material. However, the Galloway Company offers as standard either untreated or treated Redwood. Chemonited Fir will last up to ten times as long as any untreated wood species.



G. W. GALLOWAY CO. ENGINEERING DESIGN FABRICATION CONSTRUCTION

How Standard's research helps put jet aircraft in the stratosphere



Standard's new synthetic oils help conquer withering jet heat and stratospheric cold.

TEN MILES UP WHERE THE JETS FLY there's a world few men know. Temperatures from 70 to 100 below zero make ordinary lubricants thick and sluggish on controls that must respond instantly. But within jet engines, moving parts must be protected against withering heat up to 600° Fahrenheit.

Standard has "built" synthetic oils that stand up under both extremes. In less than five years these oils will be helping jet airliners whisk you safely to your destination, farther, faster, and more comfortably than ever before. We've been working toward that day since 1942 when Standard supplied the fuel used in the first jet flight in the United States.

Progress in the West means...

Air travel will nearly double by 1965

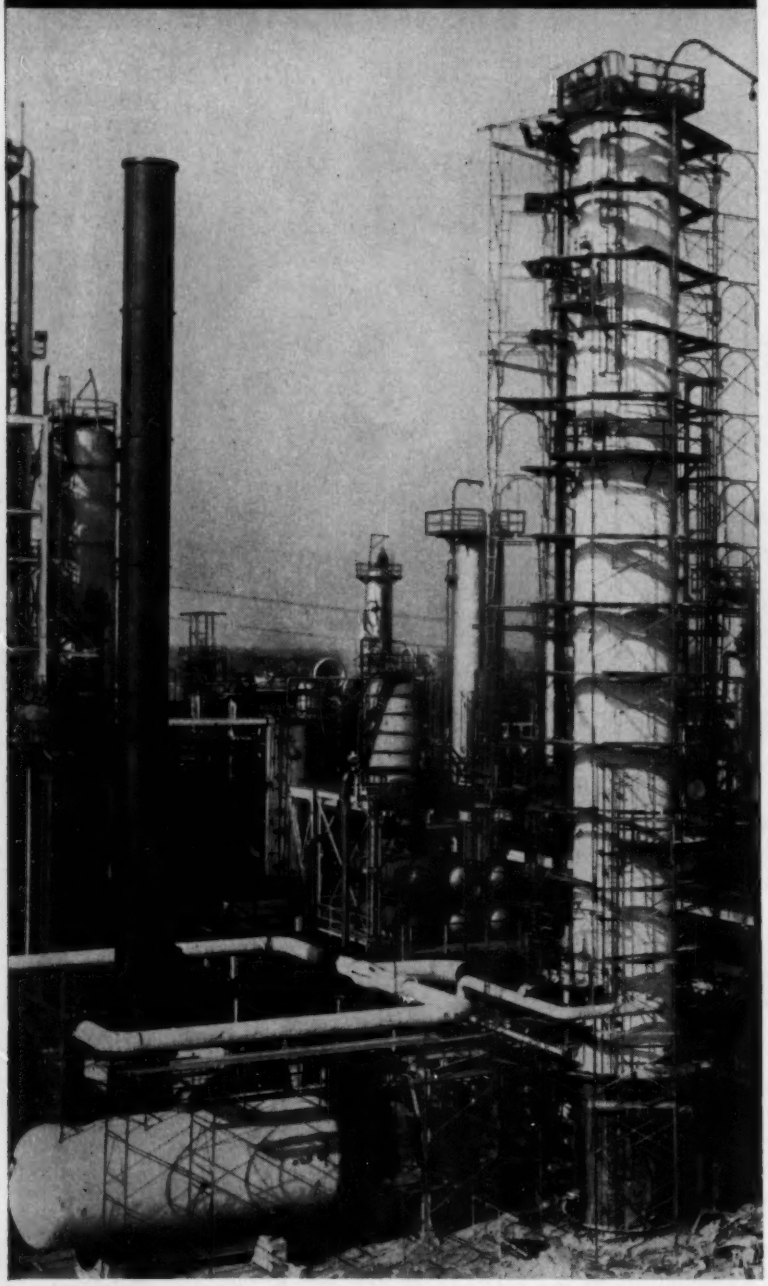
Jet airliners will carry twice as many passengers at twice the speed of conventional planes. Standard is getting ready now for 1965 when U.S. civilian and military demand for jet fuel will surpass aviation gas by more than 300,000 barrels a day.

STANDARD OIL COMPANY OF CALIFORNIA

plans ahead to serve you better

For more data on advertised products, use Readers' Service Cards, last page.

On Country's First REXFORMER® at AURORA REFINERY...



time saved by quick setting of

BALDWIN-HILL SUPER POWERHOUSE® Insulating-Finishing CEMENT

B-H SUPER POWERHOUSE CEMENT, combining insulation value with a glazed white finish, was selected instead of a straight insulating cement because of its quick setting ability and good water resistance prior to weather coating. Rain, sleet or snow does not adversely affect the cement after setting. Its application speeds work—allows other operations to proceed with little delay.

SUPER POWERHOUSE CEMENT is a dry, fibrous material having a spun mineral wool base and a fast, hydraulic setting binder. It remains workable for two hours and then takes a hydraulic set in four to five hours.

SUPER POWERHOUSE was applied directly to the rib lath on the B-H spun mineral wool BLANKETS.

See our catalog in Sweet's Plant Engineering File.

BALDWIN-HILL COMPANY

Complete Line of Industrial Insulations

709 Breunig Avenue Trenton 2, N. J.

Huntington, Ind. Kalamazoo, Mich. Temple, Texas

For more information, staple the keyed corner of this ad to your letterhead and mail.

J-33

For more data on advertised products, use Readers' Service Cards, last page.

Keep plant space flexible with BLAW-KNOX Electroforged® Steel Grating

If expanding production set-ups are cramping feeder and storage areas in your plant, it will pay you to check into Blaw-Knox Electroforged Steel Grating.

Storage platforms of Blaw-Knox steel grating put unused space to work easily, economically. There's nothing to wear, nothing to patch. Blaw-Knox Electroforged grating fits neatly around pipes, beams and machinery without any alterations to the building, and, at the same time, admits maximum light and ventilation to the entire area.

Blaw-Knox Electroforged Grating for walkways, stair treads and floors is fabricated to your specifications to meet your own operating conditions. Complete data on all types is contained in Bulletin No. 2527. Write for your copy today.

BLAW-KNOX COMPANY

Equipment Division
Dept. D, Pittsburgh 38, Pa.

For more data on advertised products, use Readers' Service Cards, last page.

ACCO for Better Values

R-P&C Valves

DESIGNED FOR DEPENDABILITY

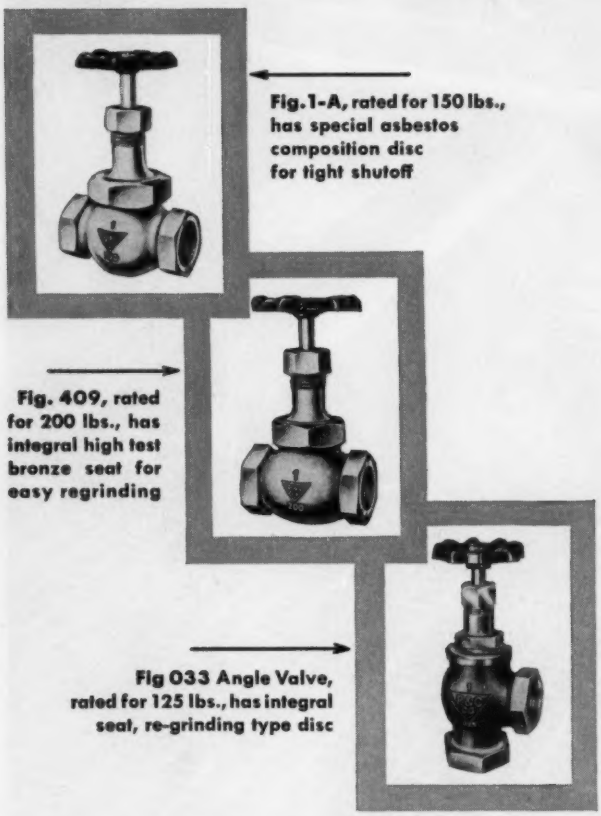


Fig. 1-A, rated for 150 lbs., has special asbestos composition disc for tight shutoff

Fig. 409, rated for 200 lbs., has integral high test bronze seat for easy regrinding

Fig 033 Angle Valve, rated for 125 lbs., has integral seat, re-grinding type disc

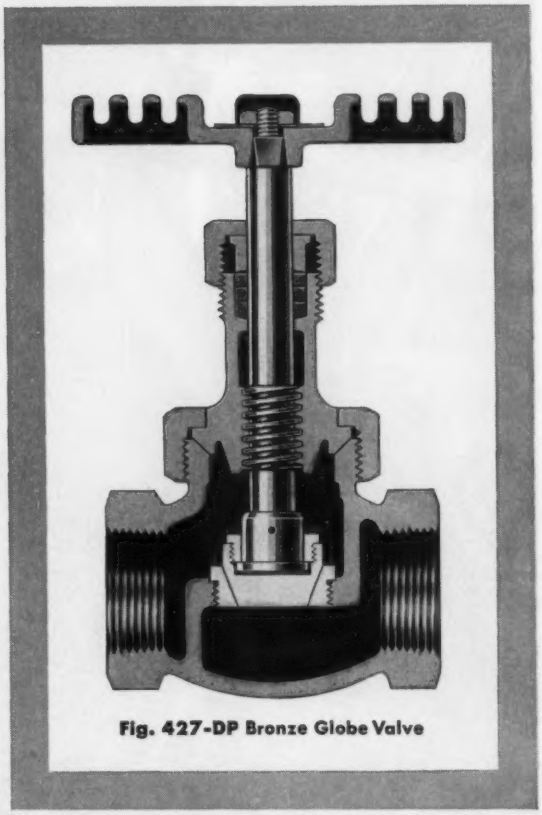


Fig. 427-DP Bronze Globe Valve

R-P&C Distributors offer 9 different models of Bronze Globe Valves—What are your requirements?

• You can select the R-P&C globe or angle valve to meet your particular requirements from a wide variety of seat and disc constructions, with union or screwed bonnet, screwed ends, in pressure classes from 125 to 300 pounds. Your R-P&C distributor offers 9 different bronze globe valves, each in a complete range of sizes—and 8 different models of angle valves which duplicate the construction features found in the globe valve line.

For example, if your application calls for frequent or continuous throttling in steam, water, oil or gas service, the **Fig. 427-DP** shown above is probably your best bet. The full plug construction gives you closer regulation. And the 500 Brinell stainless steel seat and disc resist wire drawing—give you much longer valve life.

Your R-P&C distributor can recommend the specific valve to answer your particular problem. And he has an equally wide selection in R-P&C's complete line of angle, gate and check valves in iron and cast steel, as well as forged steel gate valves. See him today.

Send for this free wall chart

"How to Protect Your Valves"

• 22 in. x 17 in. wall chart tells how to protect valves, get longer valve life—gives installation and operation pointers. Write for your copy.

R-P&C Valve Division

AMERICAN CHAIN & CABLE

Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

ACCO TRADE MARK

SCRUBOSPHERE* ...

... FOR *Cleaner Gas* AT *Less Cost!*

*PEERLESS SPHERICAL
DUST and LIQUID SCRUBBER
FOR GAS PIPELINES

(A) The majority of incoming liquid and solid particles are directed down into reservoir. 1

(B) Lighter solid particles carried by gas stream are separated on surfaces of contactor which are kept wet and clean by revolving thru liquid reservoir. 2

(C) Contactor is revolved by explosion-proof gear motor.

(D) Mist Extractor removes any remaining liquid particles from gas stream prior to outlet. 3

- **The dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes wetted surfaces for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** — The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

PEERLESS MFG. CO. DALLAS TEXAS

PEERLESS MANUFACTURING CO.

P. O. BOX 13165 DALLAS, TEXAS

Representatives in All Principal Cities

Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber.

For more data on advertised products, use Readers' Service Cards, last page.

Because the mortar

Harbison-

more than 25 different

Refractory brick structures last longer when the bonding mortar matches the characteristics of the brick. The mortar should correspond with the brick in refractoriness, thermal expansion and other properties and should be compatible in chemical composition. To fulfill the requirements for the many different types and classes of refractory brick and operating conditions, Harbison-Walker produces more than twenty-five bonding mortars.

Included in this wide range are some mortars which set with a strong bond upon drying, which is retained at high temperatures, and others which acquire a good ceramic set only when heated. The

Some of the Various Types and Classes

BRAND	DESCRIPTION	TYPICAL APPLICATIONS
HARWACO BOND wet or dry	Cold-Setting with strong bond and negligible shrinkage—alumina-silica composition—more refractory than any mortar of fireclay base.	Used for laying all classes of fireclay and high alumina brick in boiler settings—kilns—oil refining units—metallurgical furnaces.
HARWACO MASTIC wet or dry	Corresponds to HARWACO BOND in composition—especially adapted for use in thick plastic consistency.	For pointing or sealing cracks in brickwork—as a protective coating—monolithic packing back of water-wall tubes—air duct linings.
CORALITE BONDING MORTAR wet	High alumina cold-setting cement of unusually high refractoriness.	For laying all classes of alumina-silica brick used at unusually high temperatures in contact with molten metals and various corrosive slags.
KORUNDAL BONDING MORTAR dry	Cold-setting bonding mortar containing approximately 85% alumina. Mineral composition mullite and corundum. Extremely high in refractoriness.	Used for laying all classes of high-alumina brick. Very resistant to corrosion by volatile alkalies and slags of certain metallurgical furnaces.
H-W CORUNDUM BONDING MORTAR dry	Substantially an all corundum cold-setting mortar of 99% alumina content.	The ultimate in refractoriness among high alumina mortars—used with greatest benefit at highest temperatures.
THERMOLITH dry	Chrome base cold-setting mortar. Highly resistant to many very corrosive fluxes.	Most extensively used for laying magnesite, chrome and forsterite brick. Also favored for use with fireclay and high alumina brick in many special applications.

HARBISON-WALKER REFRACTORIES COMPANY
AND SUBSIDIARIES
World's Most Complete Refractories Service
General Offices: PITTSBURGH 22, PA.

is as important as the brick . . .

Walker provides BONDING MORTARS

mortars with hot-setting properties contribute to flexibility in expansion and contraction of structures which are subjected to soaking heats throughout. Chemical compositions vary from highly basic, through various degrees of neutral to strongly acid, and in each specific case provide for maximum resistance of the joints to the widely different corrosive slags and fumes. Among these compositions are those consisting largely of magnesia, forsterite (magnesium silicate) chrome, corundum (stabilized crystalline alumina), silica and alumina-silica in various ratios.

Adequate refractoriness to secure the most durable and impervious joints and smooth-working plasticity with proper water retention are other properties of major importance for these mortars.

In addition to the different kinds described in the following table, Harbison-Walker produces others, including hot-setting mortars such as H-W FURNACE MAGNESITE, H-W SPECIAL FURNACE CHROME, H-W BONDING MORTAR and various brands of finely ground high duty and super-duty fireclays as well as several modifications of silica cements and mortars primarily for laying insulating fire brick.

From these bonding mortars can be selected those best suited for each specific application to secure longest furnace life and greatest economy.

of Harbison-Walker Bonding Mortars

BRAND	DESCRIPTION	TYPICAL APPLICATIONS
H-W FORSTERITE BONDING MORTAR dry	Strong cold-setting, magnesium silicate mortar of basic character.	For use at high temperatures with H-W FORSTERITE brick in glass-melting and various metallurgical furnaces.
H-W PERIKLASE BONDING MORTAR dry	Basic, highly refractory, cold-setting mortar used for laying H-W PERIKLASE and other basic brick.	Used in electric and open hearth steel melting furnaces, glass furnaces, rotary kilns.
FIREBOND dry	Siliceous cold-setting bonding mortar having the property of high resistance to siliceous slags.	Used for laying silica brick where strong bonded joints are desirable and with fireclay brick for dense impervious joints at moderate temperatures.
VEGA BOND dry	Hot-setting silica cement of super-duty quality. Non-shrinking and smooth working.	For laying and grouting conventional and super-duty silica brick in all their applications.
ANKORITE dry	High alumina hot-setting mortar possessing excellent working qualities. Provides flexibility to brickwork in soaking heats over an intermediate temperature range and a strong set at the furnace operating temperatures.	Used for laying super-duty and high duty fireclay brick and the various classes of high alumina brick where a highly refractory heat setting mortar serves to best advantage.
H-W WEATHERED BOND B CLAY dry	Hot-setting bonding mortar. Excellent plasticity and bonding qualities developed by a long weathering process.	Used with splendid results for laying fireclay brick in boiler settings, iron blast furnaces and stoves.

Use this coupon to get prices and additional information about Harbison-Walker Bonding Mortars

Harbison-Walker Refractories Co.
Pittsburgh 22, Pa.

Please send me prices and information about the following bonding mortar(s)

_____

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NAME_____ POSITION_____

COMPANY_____

ADDRESS_____

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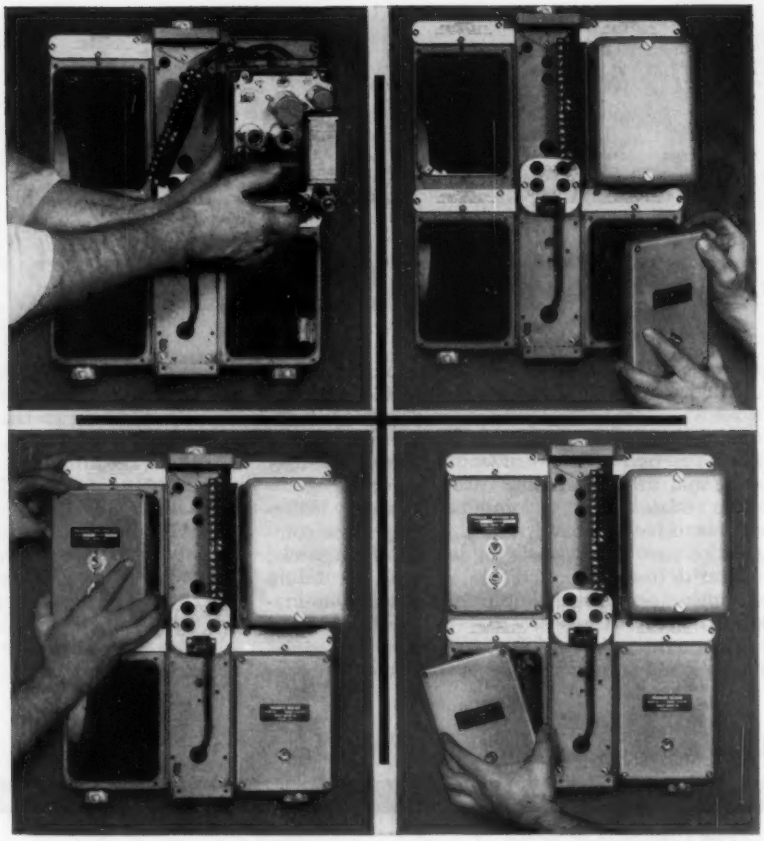
CUSTOM BUILD your own Bailey Recorder



These four views of the back of a Bailey Recorder show how four plug-in units may be added as needed to meet almost any recorder application.

The freedom and flexibility of "do-it-yourself" instrumentation is yours in the Bailey Recorder. A variety of plug-in units make it possible to record, control, and retransmit any variable that can be converted to a pneumatic or electric signal.

The basic plug-in units are the Bailey a-c and d-c Electronic Receivers and Pneumatic Receivers. Any four of these may be used in one recorder, intermixed in any way, to provide four continuous records on one chart.

For automatic control, other plug-in units are available.

For square root extraction or linear integration, there are two plug-in variations of the Bailey Integrator.

When you want a pneumatic signal that varies according to a pre-set pattern plug in a Bailey Program Controller.

Periodic running time of a condition or process is recorded on the chart when a Bailey Running Time Recorder is used.

These and other plug-in units are described in Product Specification E12-5. Some companies stock Bailey Recorder cases and assorted plug-in units. As instrumentation and control needs arise they build up the kind of recorder-controller required, using the proper plug-in units from stock. Unmatched versatility such as this means lower instrumentation costs.

For the complete story of how easily you can custom build this recorder to your needs, see your Bailey Engineer. G43-1

BAILEY METERS

Instruments and controls for power and process

BAILEY METER COMPANY

1043 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

FUNGI AND BACTERIA STOPPED DEAD WITH CSC TRIS-NITRO

Ideal in Cutting Oils, Oil Well Flooding, Pipe Lines and Drilling Muds

Tris-Nitro—Tris (hydroxymethyl) nitromethane—checks unwanted microbiological growth in aqueous systems. Long known as a hardening agent for proteins under slightly alkaline conditions, Tris-Nitro is a powerful inhibitor of microorganisms as well.

SLOW RELEASE OF FORMALDEHYDE APPARENT SECRET OF SUCCESS

The inhibition mechanism of Tris-Nitro is apparently due to the gradual release of formaldehyde which offers sustained protection for a prolonged period. Recent experiments show that formaldehyde is also slowly released at high humidities and high ambient temperatures in the presence of a trace of alkaline material. Tris-Nitro may also be useful in its dry form to protect packaged goods from mold attack during shipment and storage.

TRIS NITRO'S PROPERTIES ARE WORTH LOOKING OVER

Formula	$(CH_3OH)_3CNO_2$
Molecular Weight	151.12
Melting Point, °C	165-170 d
pH of 0.1M Aqueous Solution	5.6
Solubility in Water, g/100 ml at 20°C	220

CUTTING OIL SYSTEM FULLY PROTECTED WITH JUST 0.1% TRIS-NITRO!

More than 200 compounds were tested in open cutting oil systems. Only 0.1% Tris-Nitro kept system free of bacterial contamination for over 60 days — longer than any other compound tested!

GET SAMPLE AND FURTHER INFORMATION. TO HAVE A REPRESENTATIVE DISCUSS APPLICATIONS WITH YOU, WRITE CSC TODAY.

COMMERCIAL SOLVENTS CORPORATION
INDUSTRIAL CHEMICALS DEPT.
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Louisville...Memphis
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New York...Pittsburgh
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IN MEXICO: Comsolmex, S. A., Mexico 11, D. F.

DISCOVER THE NITROPARAFFINS!

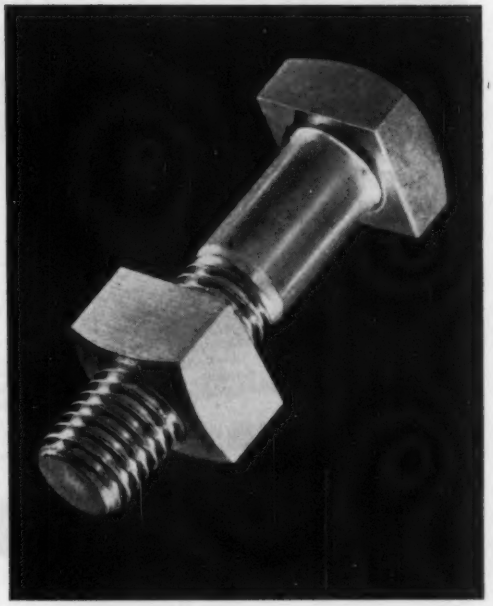
when new aluminum coating holds up so well

On galvanized structures, the rusting caused by atmospheric corrosion usually begins with the bolts and nuts. In time, this presents a serious maintenance problem. But now, at slight extra cost, you can obtain coated fasteners which are so rust-resistant that they outlast any other part of a galvanized structure. These fasteners are coated with Bethalume, Bethlehem's new aluminum coating.

The Bethalume hot-dip coating makes possible a much longer service life for fasteners by adding the corrosion resistance of aluminum to the strength of steel.

Bethalume coatings stand up especially well under "heat-corrosion," at lower cost than products customarily used. Moreover, the Bethalume coating is unusually uniform—not merely on the body of each bolt, but over the entire threaded portion as well, thus making possible threads which are clean and smooth-fitting.

We have a new illustrated booklet on the Bethalume coating, which describes its advantages in detail. If you would like to have a copy, just drop a line to the Bethlehem office nearest you.



BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

VALVES

to control anything but rain!

My Boss buys a lot of valves — or has it done — and he sure likes to buy them from J&L Supply.

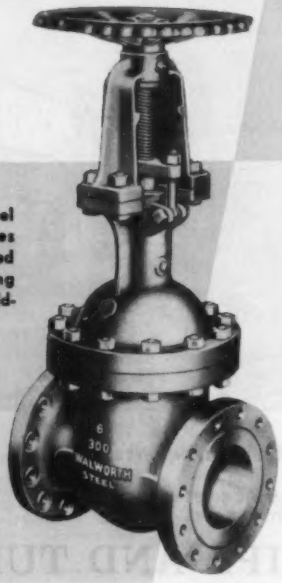
"Give those people the facts," says he, glancing at my new raincoat, "and they'll come up with the perfect valve for handling anything but rain."

"And what do we mean by the 'facts'?", says I, eager to be a good secretary.

"Oh," says he tolerantly, "to get the perfect valve for exacting jobs, we just give J&L complete service information: size and flange rating and facing, fluid to be handled, operating pressure, maximum temperature, any special corrosive conditions — that sort of thing."

"Oh?" says I.

"Young lady," says he, sensing my confusion, "don't expect to learn all about valves in a day. J&L Supply usually recommends Walworth, and Walworth was making and improving valves before your great granddaddy was born!"



Walworth Cast Steel Gate Valve, Series 300. Can be supplied with Roller Bearing Yoke and Butt Welding End.

29-O

Jones & Laughlin

SUPPLY DIVISION – Tulsa

SERVING THE UNITED STATES AND CANADA

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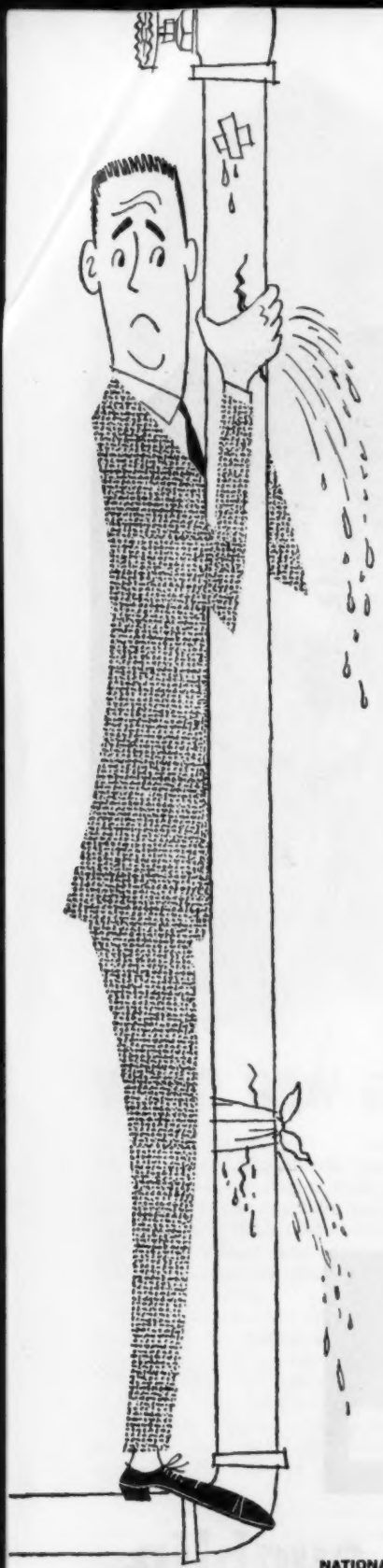


You say you have a pressure problem?

Nothing serious, we hope. But if you'd like some assistance with it just call on "National Tube." Pressure problems are our specialty. So are temperature problems, acids, oxidation, corrosion—in fact, all types of refinery tubing problems. We like to solve them.

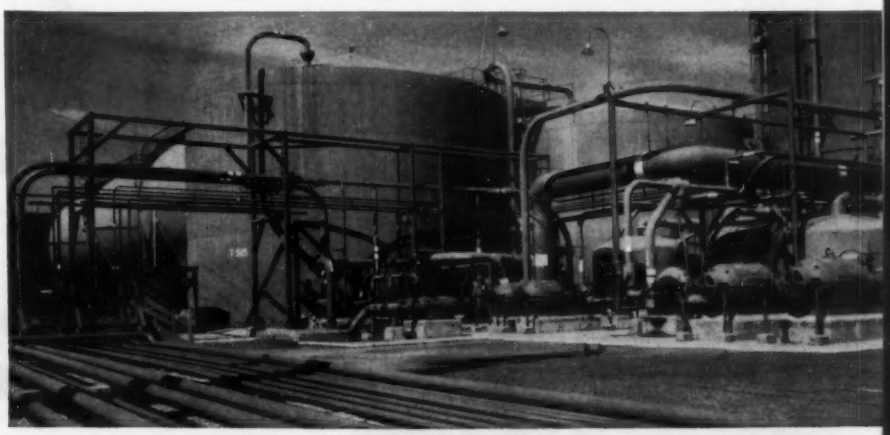
You see, we have a system. Here, at National Tube, we've kept case histories for many years—data on thousands of tough refinery tubing problems, each one solved by a specially prepared steel alloy. The result of this accumulation of knowledge is concentrated in 24 different steel tube analyses, each designed to combat a specific set of refinery conditions. Long, rigorous testing in actual refinery service has proved the capabilities of every one of these analyses.

In addition to these two dozen analyses, other chemical compositions are available in tubular products, and a wide variety of temperature problems is presently under study.

So, get in touch with us. Our Mill Service Force, available for field consultation, will help you find just the alloy you need, at the right price, to meet your refinery conditions. Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

HERE ARE NATIONAL TUBE'S TWO DOZEN DIFFERENT TUBE ANALYSES:

Carbon	5 Cr, ½ Mo	17 Cr
Carbon, ½ Mo	5 Cr, ½ Mo, 1½ Si	18-8
1 Cr, ½ Mo	7 Cr, ½ Mo	18-8 Ti
1¼ Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
2 Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo
2¼ Cr, 1 Mo	9 Cr, 1 Mo	25-20
2½ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
3 Cr, 1 Mo	12 Cr, Al	5 Ni



NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

SEAMLESS WITHOUT WELDS

NATIONAL SEAMLESS PIPE AND TUBES

UNITED STATES STEEL

Struthers Wells

STOCK Heat Exchangers Save you money!

Code Equipment at Production Prices

Struthers Wells standard stock heat exchangers have secured a wide acceptance in the process industries.

The illustration shows a partial view of units currently in stock. Equipment is available from stock in sizes from 20 to 300 square feet of surface—including fixed tube sheet, floating head and U-tube units.

Condensers, coolers, heaters, and reboilers can be supplied in single and multi-pass tube arrangement.

Standard heat exchanger construction includes materials of carbon steel, non-ferrous alloy, and stainless alloys Type 304 and Type 316. Equipment meets highest construction standards, including ASME Code and TEMA Class A.

Standardization of design and quantity production enables us to offer this equipment at a very reasonable cost.

Price sheets and standard data are available on request; please address us on your letterhead.

STRUTHERS WELLS PRODUCTS

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Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

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BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

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MACHINERY for Sheet and Structural Metal Forming . . . Tangent Benders . . . Folding Machines . . . Roller Table and Tumble Die Bending Machines . . . Press Brakes . . . Punching and Notching Machines . . . Forming Dies

ANY SIZE AVAILABLE FOR QUICK DELIVERY

STRUTHERS WELLS Corporation

Struthers Wells

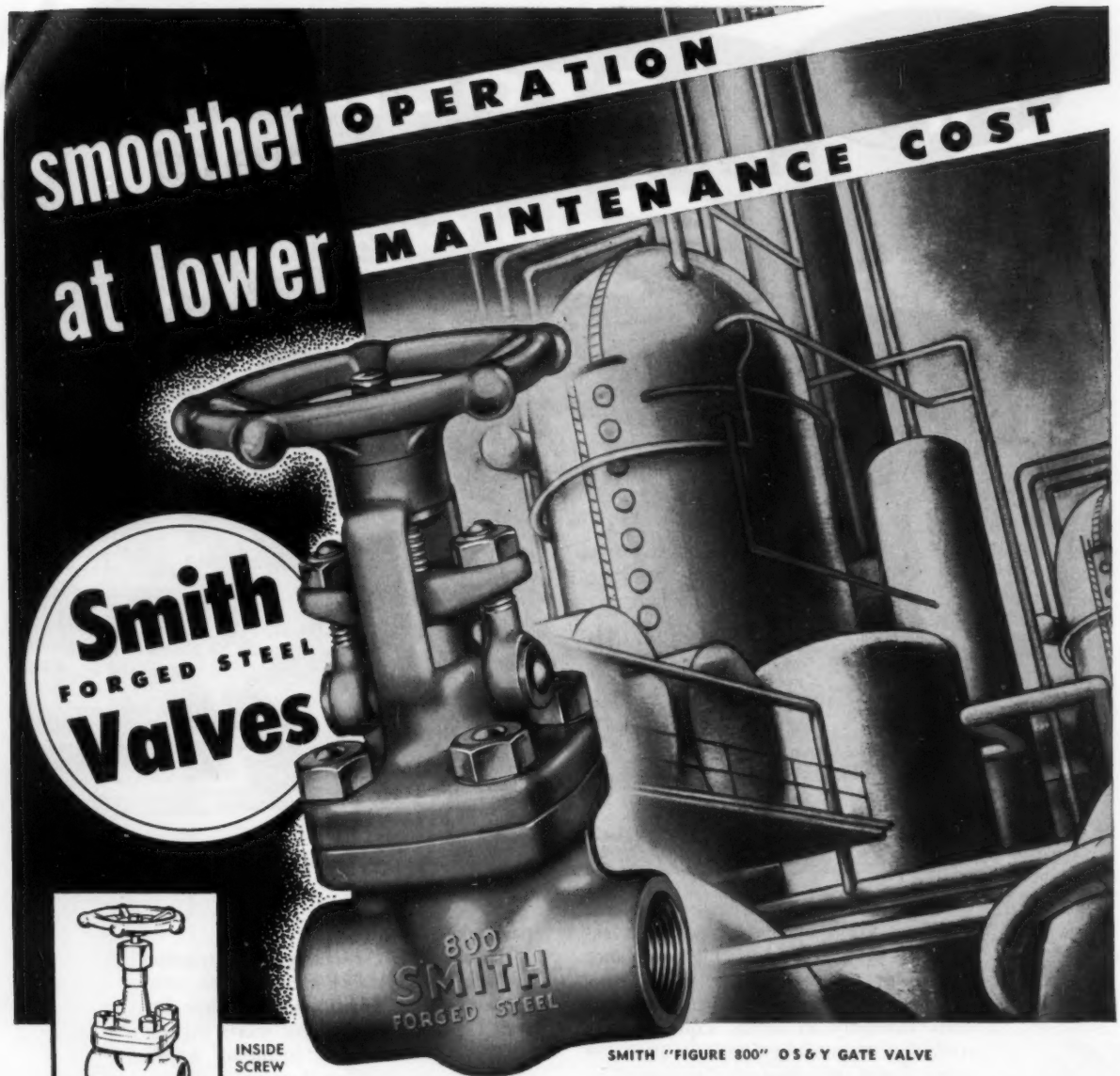
WARREN, PA.

Plants at Warren, Pa. and Titusville, Pa.

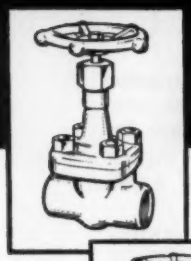
Offices in Principal Cities

smoother OPERATION at lower MAINTENANCE COST

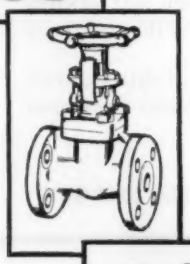
Smith FORGED STEEL **Valves**



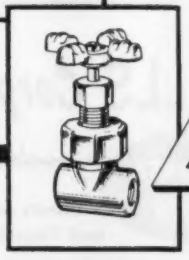
SMITH "FIGURE 800" O S & Y GATE VALVE



INSIDE SCREW VALVES



FLANGED END GATE VALVES



NEEDLE GLOBE VALVES

A combination of features, especially designed and precision-built to meet the exacting needs of the Refinery and Petrochemical industries, make SMITH VALVES your surest approach to smoother operation at lowest possible maintenance cost.

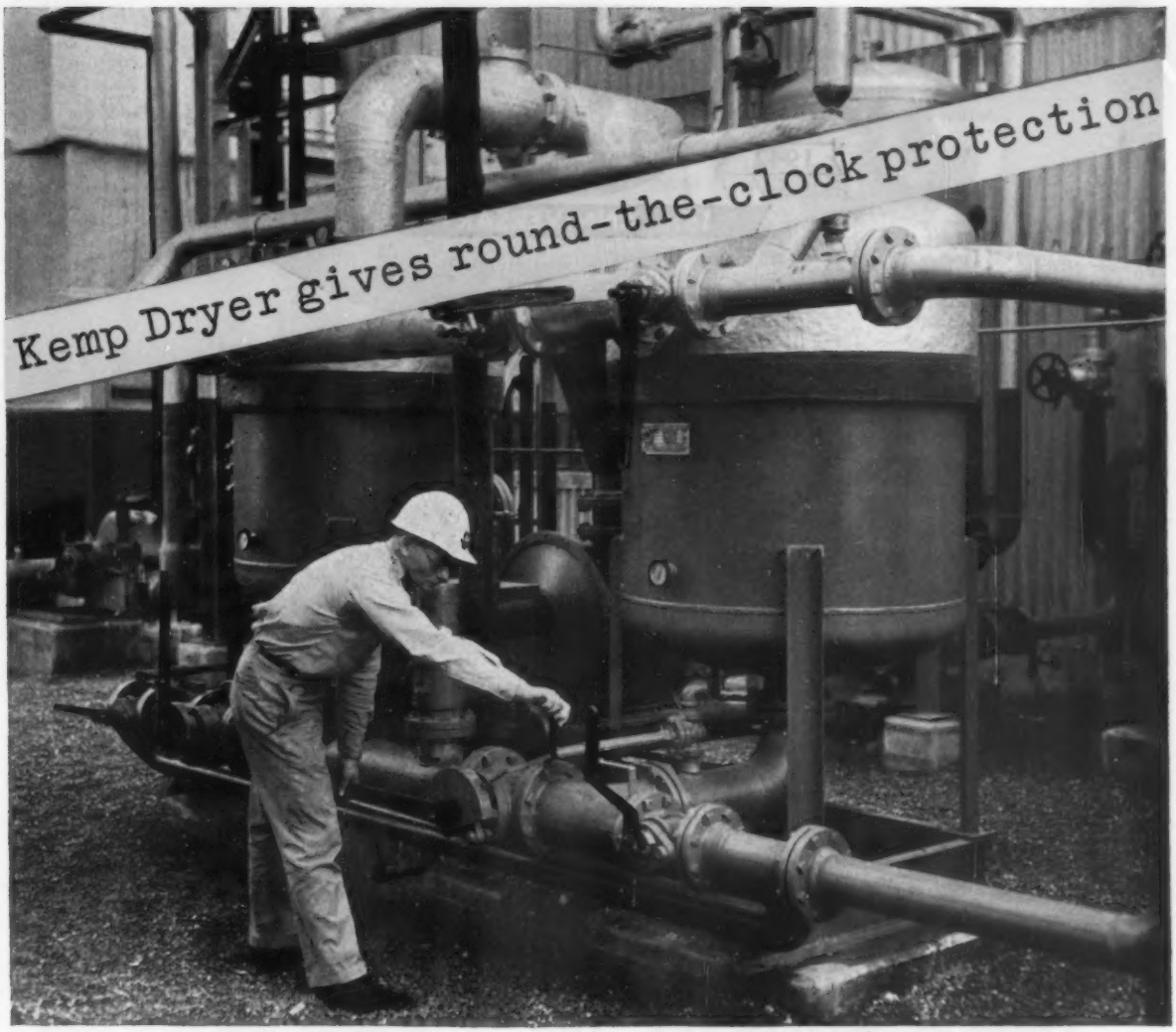
- STEMS — heat treated to "375 Brinnel" for extra toughness with 30% stronger *rolled threads* which eliminate chatter or cutter marks.
- GATES — "tear drop" design with accurately broached gate guides minimizes scuffing and insures perfectly controlled operation at high temperatures and pressures.
- SEATS — diamond-hard chrome faced seats in combination with "500 Brinnel" gates prevent seizing, galling and abrasive wear.
- Bolted bonnet design and flexitallic gaskets insure lower cost installation, easier maintenance and repair.

Write today for literature giving complete details and prices.

NEW ENGLAND VALVE *Corporation*

P. O. BOX 1047 • WORCESTER, MASSACHUSETTS

West Coast Distributors: BETHLEHEM SUPPLY CO., LOS ANGELES, CALIFORNIA



Grace Chemical Company Reports: *Kemp Dryer safeguards instruments throughout plant 24 hours per day*

The Grace Chemical Co. manufactures Anhydrous Ammonia and Urea 24 hours a day at Woodstock, Tenn. This operation demands instrument accuracy with a minimum of maintenance and downtime. To increase instrument efficiency by preventing corrosion and costly line freezes, Grace Chemical installed a Kemp Dryer.

Kemp Requires Little Attention

Semi-automatic, the Kemp Dryer works night and day drying compressed air for instruments and pneumatic controlled valves. According to operator Charles Lewis, the Kemp unit requires a bare minimum of attention.

Kemp Dryers for Every Purpose

Kemp offers a variety of dryer models to meet all problems. Designed to dry air, gases or liquids to sub-zero dew points at a low cost, they are constructed of quality materials and embody the engineering knowledge gained from Kemp's many years of experience. Kemp Dryers are available with manual, semi-automatic, or fully automatic tower reactivation. In addition, Kemp will prescribe the proper desiccant for each drying job. If you have a problem involving the removal of water from air, gases, or liquids, contact Kemp engineers now. For complete facts and technical information, write for Bulletin D-27.

KEMP
OF BALTIMORE

DYNAMIC DRYERS

CARBURETORS • BURNERS • FIRE CHECKS
METAL MELTING UNITS • INERT GAS GENERATORS
SINGEING EQUIPMENT

THE C. M. KEMP MFG. CO.
405 East Oliver Street, Baltimore 2, Maryland

For more data on advertised products, use Readers' Service Cards, last page.

1942 TRECO 1957

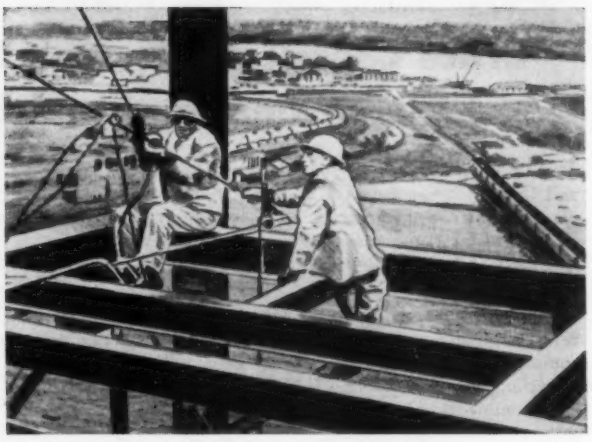
15th ANNIVERSARY

15 Years of Progress

TRECO'S first job in 1942 was a small contract from Ashland Oil Refining Company of Ashland, Kentucky. The prompt and efficient execution of this contract brought several more as each preceding one was completed.

From this small beginning in the refining industry, our firm has expanded into the fields of petro-chemicals, rare earths and ores. Our staff has continued to expand as have the areas of our operations until today, no job is too large or too far from our home base. Every contract receives the same prompt and efficient execution as our first.

Now, on our 15th Anniversary, we are most grateful to those companies whose first contracts played such an important part in our operations.

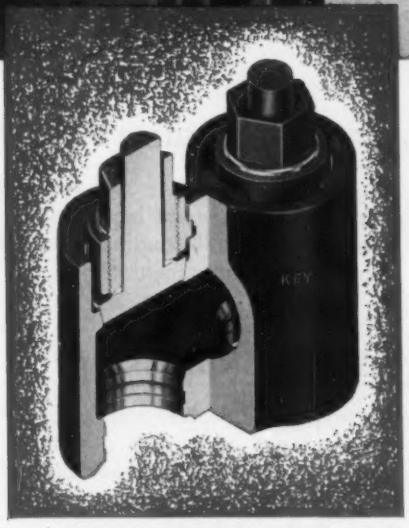


TRECO

A DIVISION of VITRO CORPORATION of AMERICA

The REFINERY ENGINEERING Company

NEW YORK TULSA TORONTO



KEY Fittings have many distinct advantages, including simple design for easier maintenance and repair, fewer parts for less inventory and cost, rugged construction of any desired alloy for long life and safety, ample corrosion allowance, streamlined crossover port for minimum pressure drop and turbulence.

KEY® 5000 TYPE FITTINGS

Serve Socony Mobil Paulsboro Refinery

The heater in this modern refinery is equipped with new patented **KEY** 5000 type return bend fittings. Leading refineries everywhere use these fittings because they offer dependable and lasting service with real economy.

Our Bulletin No. KR-1057 contains complete details about the full line of **KEY** 5000 type fittings. Write now for your free copy.

Address Dept. M-9 for your copy of Bulletin KR 1057 by return mail.

W-K-M

DIVISION OF acf INDUSTRIES INCORPORATED

PLANT: MISSOURI CITY, TEXAS
MAILING ADDRESS: P. O. BOX 2117, HOUSTON, TEXAS

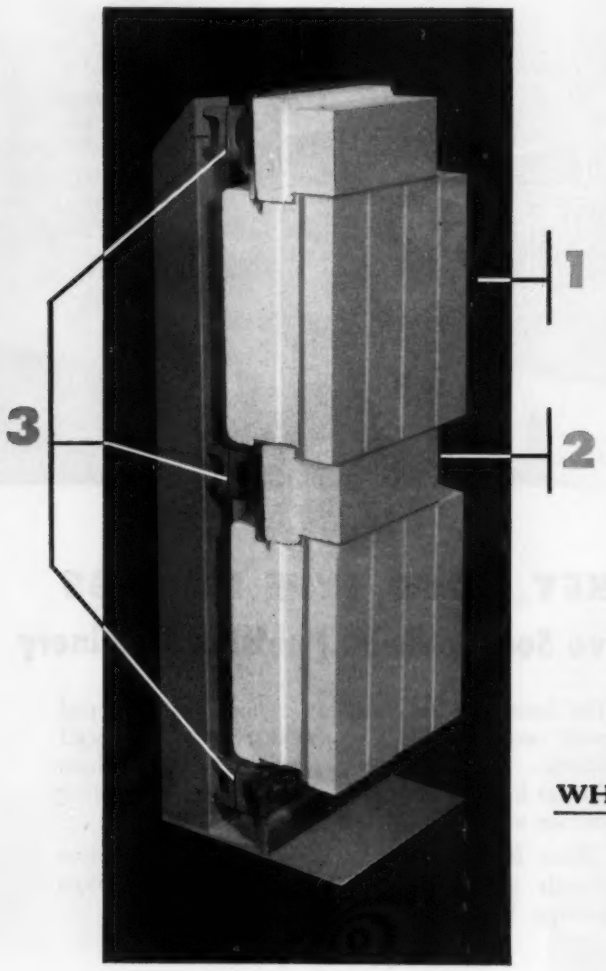
9715

MANUFACTURERS OF W-K-M GATE VALVES · acf LUBRICATED PLUG VALVES · KEY-KAST ALLOY STEEL PIPING FITTINGS · KEY RETURN BENDS AND FITTINGS

IDEA FILE:

Big problem these days is saving money on capital goods equipment —without sacrificing performance. A combination of ideas from Bigelow-Liptak's engineering department involves the use of two established wall designs • • •

LIKE THIS:



IDEA and SAVING NO. 1

Use a seven-inch tile for maximum refractory thickness.

IDEA and SAVING NO. 2

Employ a five-inch filler tile. (Place insulation or fire clay in front of supporting casting.)

IDEA and SAVING NO. 3

Increase space between horizontal castings and eliminate a number of castings.

and—for FLEXIBILITY

Air cool the wall—or use economical thicknesses of block and plastic insulation depending upon temperature requirements.

WHERE THIS DESIGN IS USED:

For refinery oil heaters, municipal incinerators or power plants where economy is a must, but where performance has got to be good. Write for details.

BIGELOW-LIPTAK
CORPORATION
AND BIGELOW-LIPTAK EXPORT CORPORATION
13300 PURITAN AVENUE, DETROIT 27, MICHIGAN

UNIT-SUSPENDED WALLS AND ARCHES

IN CANADA
BIGELOW-LIPTAK OF CANADA, LTD.
TORONTO, ONTARIO

ATLANTA • BOSTON • BUFFALO • CHICAGO
CLEVELAND • DENVER • HOUSTON
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ST. PAUL • SALT LAKE CITY • SAN FRANCISCO
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SAULT STE. MARIE • VANCOUVER • WINNIPEG

For more data on advertised products, use Readers' Service Cards, last page.

for cooling tower application...

There's MORE protection against humidity in Allis-Chalmers MOTORS

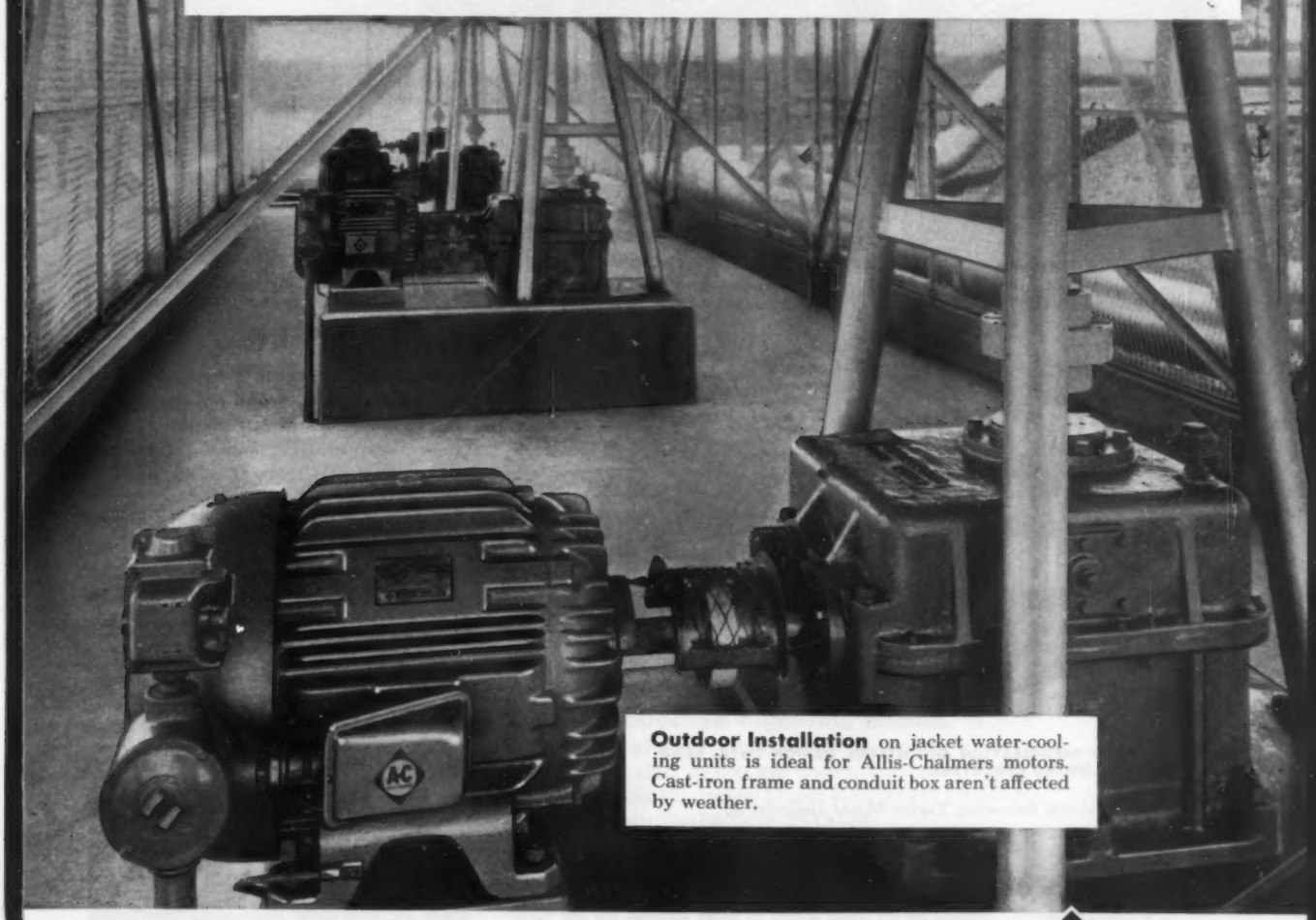
The ultimate in protection against high humidity — major cause of cooling tower motor failure — is provided tower builders and users in Allis-Chalmers TEFC motors. Here's why:

1. Moisture drainage — Drain plug can be removed to eliminate condensed moisture in the motor. (Particularly helpful in intermittent operations where condensation is more likely.)

2. Extra-insulated stator — Several applications of special insulating varnish plus repeated baking keep humidity out . . . give the long electrical life you need.

3. Weather-protected bearings — Rotating seal, turning in close running clearances, guards against entry of water.

Find out more about the "MORE" in Allis-Chalmers motors by contacting your nearby A-C sales office or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wis.

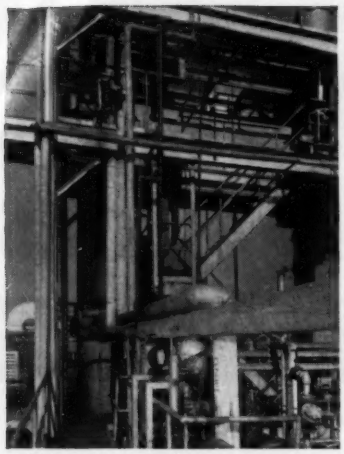


Outdoor Installation on jacket water-cooling units is ideal for Allis-Chalmers motors. Cast-iron frame and conduit box aren't affected by weather.

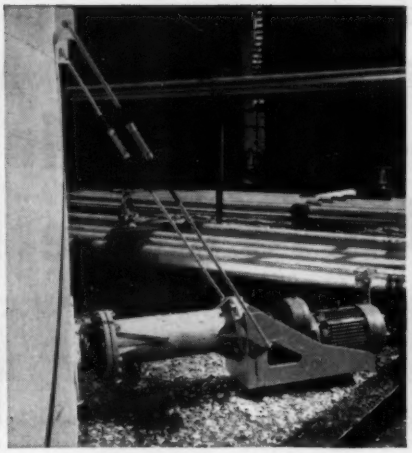
ALLIS-CHALMERS

A-C ALLIS-CHALMERS

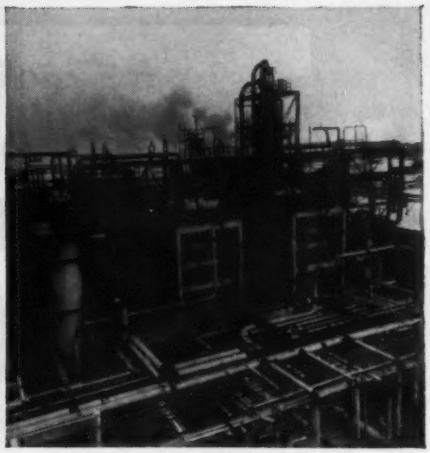
A-5183



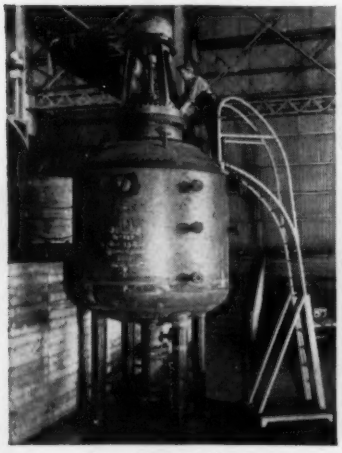
RDC Countercurrent Extraction Column
Handling a Total Flow of 2500 GPH



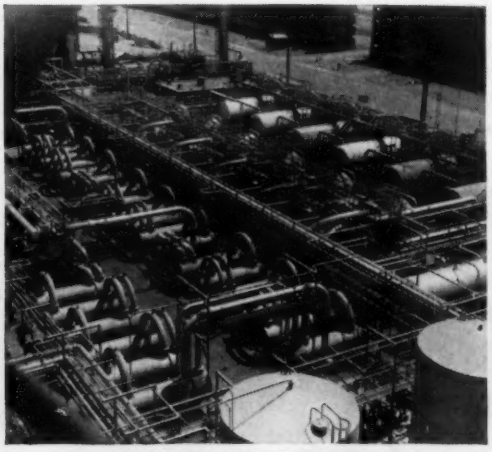
Side Entering Propeller Mixer
Blending Asphalt Cutback Products



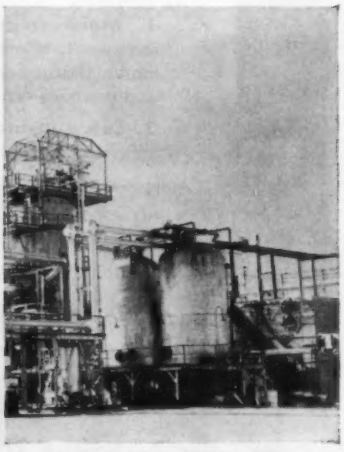
Clay Contactor Treating 135 GPH
Stream of Oil



Three Stage Continuous
Butane Isomerization Unit



Series of Three Stage Treaters and
Settlers in CAA—Butadiene Extraction



14,000 Gallon Asphalt Oxidizers
of 1000 cfm Air Capacity each

Only TURBO gives you all three... skill—facilities—experience

No mixing service is too large or too small for our staff of designers, engineers and skilled craftsmen, nor for the facilities of our plants. In support of the *high*-production, *low*-maintenance equipment shown here is more than 40 years of specialization in this field. Back of this equipment, too—a testing and research laboratory that enables our designers to custom-build Turbo-Mixers for *your* individual requirements.

Send for descriptive information showing how Turbo-Mixers can increase your production efficiency at lower cost.

FOR DETAILED INFORMATION AND USEFUL DESIGN DATA, SEND FOR THE FOLLOWING BULLETINS:

Please send me the following Turbo-Mixer Bulletin (s):

General Turbo-Mixer Bulletin_____

RDC Extraction Column Bulletin_____

Side Entering Propeller Mixer Bulletin_____

Absorption & Oxidation Bulletins_____

TURBO-MIXER GENERAL AMERICAN

TURBO-MIXER DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION

Sales offices: 380 Madison Avenue, New York 17, New York • General Offices: 135 South LaSalle Street, Chicago 90, Illinois • Offices in all principal cities

Kill Algae

Get SAFE, QUICK CONTROL at Low Cost

Allis-Chalmers No. 120 Series Algaecide eliminates fouling of cooling tower systems by algae and slimes

Check the many exclusive advantages of Allis-Chalmers No. 120 Series algaecide:

- Easy to introduce into the system by means of pump, drip feed or manual feed. No expensive feeding equipment required.
- Safe to handle. Even in concentrated form, it is no more than a mild irritant to skin, eyes and mucous membranes.
- Low toxicity to fish or animals.
- Non-oxidizing.
- Inhibits corrosion.
- Dosage is independent of organic, ammonia, or nitrogen content of makeup water.
- No loss on passage through tower.
- Proved effective in field use.
- Only 2 to 5 ppm required for effective dosage of most organisms.

This is the most effective algaecide known. If you have a problem with plugged pump strainers, coated heat exchanger tubes, coated slats in cooling towers, call your nearby A-C office, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin, for Bulletin 28X8434.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5442

For more data on advertised products, use Readers' Service Cards, last page.

the tougher the water problem
the better we like it!
BETZ
CONSULTANTS ON INDUSTRIAL WATER PROBLEMS
BETZ LABORATORIES INC., Philadelphia 24, Pa.

NOW
from Allis-Chalmers

Pushbutton stations designed to withstand even the most Corrosive Conditions

Here is one of the most practical developments to come along in recent years—Allis-Chalmers heavy duty pushbutton stations. From the phenolic BM-2498 enclosure to the Type 316 stainless-steel hardware, this line of pushbutton stations is exceptionally resistant to corrosive action of chemicals.

For the first time a proven-in-service, roll-action operator is completely protected by a rugged, corrosion-resistant enclosure. This assures longer, trouble-free operation in chemical plants, refineries, paper mills, or any industrial application where corrosive atmospheres normally cause pushbutton failures.

The complete line of Allis-Chalmers corrosion-resistant pushbutton stations includes:

- single or two-button units
- momentary or maintained contacts
- lockout attachment
- pilot lights

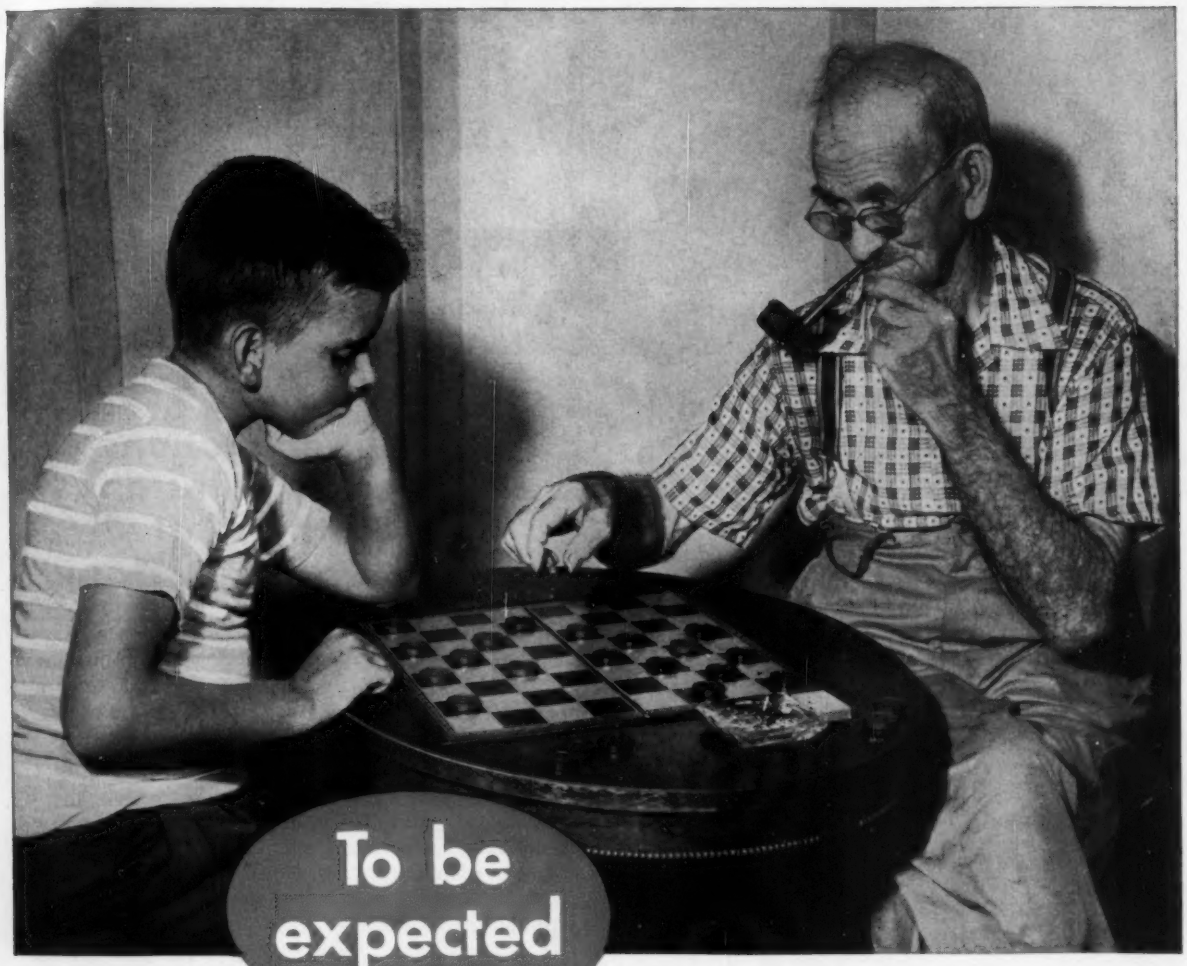
This newly designed pilot light has the same phenolic enclosure as the pushbutton stations, and is available as either single or double units. Wide angle lenses of flexible vinyl plastic have greater range of visibility, and are available in any combination of red, green, amber, blue, or white. Bayonet-type bulbs are used to resist shock. Primary voltages are to 550 volts; secondary voltage is 6.3.

For further details call your nearest A-C District Office or Distributor . . . or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-5526

For more data on advertised products, use Readers' Service Cards, last page.



Many leading power and processing plants continue to call on Mitchell for prefabricating and erecting high-temperature, high-pressure, special-process piping. They do so not solely on the basis of shop facilities but because they have learned that specialized experience pays off. On your next critical piping job, for the sake of economy, permanent safety and general satisfaction . . . ask us in.

W. K. MITCHELL & CO., INC.

Philadelphia 46, Pa.

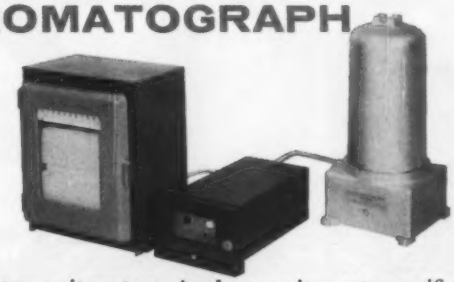
WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

Reliable, low-cost quality control with CEC's

PROCESS CHROMATOGRAPH



EXAMPLE: AVIATION GASOLINE...The three most popular alkylation processes use CEC's 26-202 Process Chromatograph for continuous monitoring of aviation gasoline quality. Finger-tip control allows treatment of end-product quality as another operating parameter, frees laboratory personnel for other projects. The 26-202 is the most practical system available today for remote control and recording, automatic sampling, automatic programming of recorded data, precise regulation of temperatures and carrier flow. *Contact your nearby CEC field office, or write for Bulletin CEC 1836-X13.*

Superior reproducibility and trouble-free, *continuous* service are provided by this completely transistorized two-unit system. Analyzer unit meets specifications for installation in Class I, Group D, Division I hazardous locations. Control unit, from its remote location, provides timing and control with precise regulation. Sample volumes are reproducible to better than ±½%. Sample and column temperatures are held within ±1°F. Variations in the carrier gas flow-rate cannot exceed ±0.1%. Voltage regulation for the thermal conductivity cell is better than 0.05%.

Consolidated Electrodynamics

300 North Sierra Madre Villa, Pasadena, California

OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more data on advertised products, use Readers' Service Cards, last page.

Instrumentation News

• News of instrumentation and automatic control in modern industry •

BRISTOL EXPANDS

Steps Up Instrument Service With New Branch Factories in Los Angeles and Houston

5 Branch Factories Plus 44 Service Centers Now Speed Instrument Service Throughout U. S. and Canada.

The new branch factories represent a major expansion of existing instrument repair and service facilities in these cities, and surrounding areas. The new branch factories are staffed with thoroughly trained Bristol field engineers and technicians and have all the equipment necessary for manufacturing standard instruments and for completely rebuilding and calibrating any Bristol instrument. (Every such factory-reconditioned instrument carries a "new" guarantee.)

The Los Angeles and Houston branch factories bring the total number of branches to five—others being located at San Francisco, Chicago and Toronto (Bristol Company of Canada, Ltd.).

The new Los Angeles branch factory, located at 6800 East Acco Street, will bring top notch instrument service to the rapidly growing West Coast electronics and aircraft industries. The Houston branch will be of particular interest to instrument users in this Southwestern center of the petroleum and petrochemical industries.

NEW PITTSBURGH HEADQUARTERS

PITTSBURGH, PA.—As part of its overall expansion, The Bristol Company announced a new and enlarged branch office headquarters at 2250 Noblestown Road, this city.

The new office will augment the already outstanding instrument service Bristol has given customers in this area since establishment of the first Bristol branch office here in 1906.

New Los Angeles Bristol Branch Factory

New Pittsburgh Headquarters

New Houston Branch Factory

"ON-THE-SPOT SERVICE" for users everywhere

WATERBURY, CONN.—The recent opening of new branch factories and offices will step up on-the-spot services for Bristol instrument users, wherever located.

Bristol customers services begin long before an instrument is purchased and continue long afterward. Bristol field and application engineers, throughout the U. S. and Canada, are available to recommend equipment best suited to your job.

NO AXES TO GRIND

You are assured of an unbiased recommendation because Bristol makes almost every kind of instrument — full size, miniature, electronic, pneumatic, electric, mechanical. Bristol process instrument specialists are ready to advise you on up-to-the-minute control systems for new tough or unusual processes.

After purchase, you have available on short notice—often within a few hours—a nationwide staff of factory-trained, widely experienced Bristol service engineers. For a reasonable rate, they install, check, adjust and inspect Bristol instruments in your plant. You can arrange to have a Bristol service engineer call at regular intervals to keep equipment in top operating condition.

Complete factory reconditioning is now available at 5 factories: San Francisco, Los Angeles, Chicago, Houston, the main factory at Waterbury, and the Bristol Company of Canada, Ltd., Toronto. Write for full particulars on Bristol instruments or service. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. 7.25

BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Now!

Davison

antioxidants

Davison, long the leading catalyst supplier, now offers two antioxidants to the refining industry . . . Dav-Ad 101 and Dav-Ad 102.

You'll find these antioxidants offer more advantages than other types for use in a long list of products: motor and aviation gasoline; turbine, transformer and lubricating oils; jet fuels; synthetic lubricants; various plastics; rubber; asphalt tile; waxes; industrial fats and oils.

Dav-Ad 101 is available in 100-pound fiber drums ... Dav-Ad 102 in 55-gallon steel drums containing 400 pounds net, or in tank car lots. Stocks are located at Baltimore, Md., Lake Charles, La. and Cincinnati, Ohio for your convenience.

Write today for samples, specifications and prices.

Progress Through Chemistry

DAVISON CHEMICAL COMPANY

Division of W. R. Grace & Co.

Baltimore 3, Maryland

SALES OFFICES: Chicago, Ill.; Houston, Tex.; New York, N. Y.; Baltimore, Md.; San Francisco, Calif.; Tulsa, Okla.
In Canada: Davison Chemical Company Ltd., Toronto.

For more data on advertised products, use Readers' Service Cards, last page.

Alumalife® Case

Phenol Case

Why do ASHCROFT DURAGAUGE CASES increase service life?

Duragauge casings add extra-long service life to Duragauges because they're available in three different materials: you can choose the case-material that stands up best in *your application*. You have a choice of *Alumalife®* – a special aluminum alloy; *Cast Iron*, rugged and durable; and *Phenol*, a tough, rigid plastic.

Duragauge casings are dust and moistureproof. Chrome-plated, die-cast retaining rings keep the dial cover glass tightly in position and prevent the entrance of dirt or harmful fumes. Depending upon material, casings are Bonderized and the ring is Anodized and dichromate sealed for protection from corrosion.

For added protection, there is the Maxisafe Duragauge casing with a solid front – a special design for maximum safety and ease of maintenance. Duragauges are easy to service since Duragauge casings are constructed so that the entire system – socket, tube, tip, movement, dial and pointer—can easily be removed as a unit.

Lifetime Duragauge cases are available for numerous dial sizes. You have a choice of Bourdon tube materials, a wide range of pressures, and a movement made completely of stainless steel or stainless steel with nylon bearings and pinion gear.

Whatever case material and gauge system is best for your needs, you can rely on the Ashcroft Duragauge for highest sustained accuracy and long service life.

FOR PROMPT ASSISTANCE in selecting the right Ashcroft Duragauges for your specific needs, depend on the experience of your Industrial Supply Distributor. He is as close as your telephone.

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

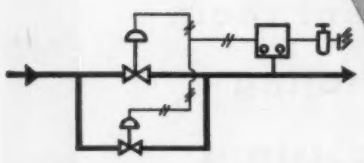
ASHCROFT GAUGES

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

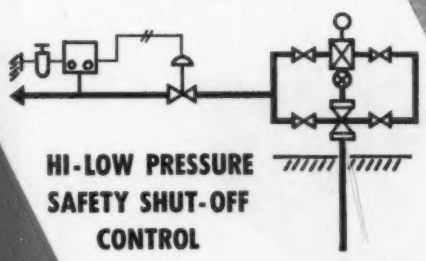
MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.* AIRCRAFT CONTROL PRODUCTS, *Danbury, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

For Optimum Pressure Control, Specify BS&B 72-14 Pressure Controllers And Transmitters!

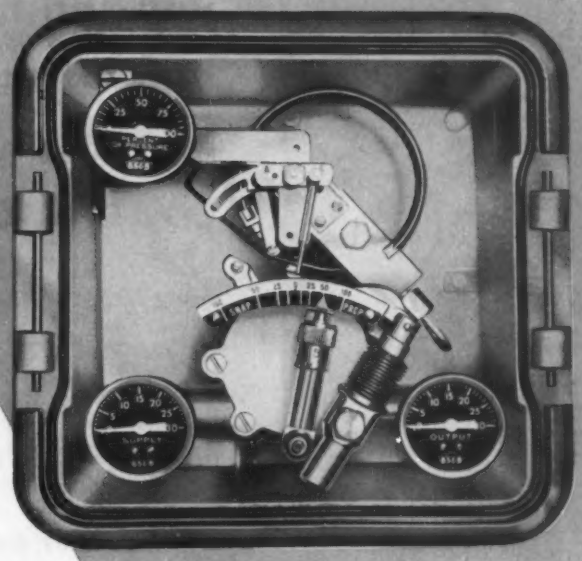
Proportional ★ On-Off ★ Differential Gap
Indicating Or Non-Indicating

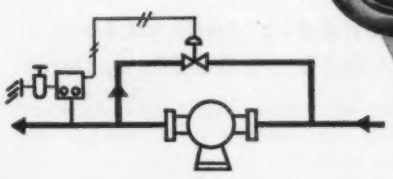


PRESSURE REDUCING CONTROL



HI-LOW PRESSURE SAFETY SHUT-OFF CONTROL

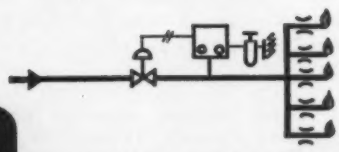




BACK PRESSURE CONTROL

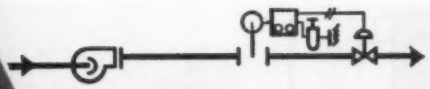
FEATURES OF POWER UNIT:

- Three-To-One High Capacity Relay
- Vibration Proof
- Push Button Cleanout
- Factory Calibrated Feed-Back Bellows
- Micrometer Adjustment



LOW PRESSURE CONTROL

Ask Your BS&B Sales Engineer For Full Details, Or Write For Catalog 72-14.



DIFFERENTIAL PRESSURE ...FLOW CONTROL

OVER 60 YEARS BS&B ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

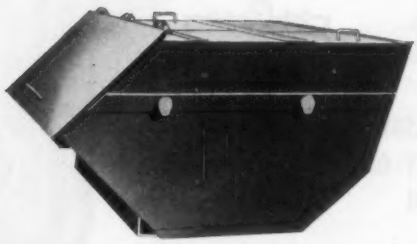
BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-F9
7500 East 12th Street
Kansas City 26, Missouri

For more data on advertised products, use Readers' Service Cards, last page.

DISASTROUS FIRES

you can help prevent them by storing and handling materials in fire-resistant LOAD LUGGER CONTAINERS



...another advantage of the modern LOAD LUGGER system

Fire is confined within the steel container, is easy to control and extinguish, often doesn't spread beyond the smoldering stage. The container, fire and all, can be readily moved to a safe area. Consider this Load Lugger advantage when you investigate materials handling equipment. Write today for full information about the Load Lugger system—Load Lugger equipped truck servicing dozens of patented Load Lugger containers. You'll be money ahead.

LOAD LUGGER BW

LOAD LUGGER, Ingersoll KALAMAZOO DIVISION
BORG-WARNER CORPORATION
1899 North Pitcher Street, Kalamazoo, Michigan, Telephone Fireside 5-3501
EXPORT SALES: BORG-WARNER INTERNATIONAL CORPORATION, CHICAGO

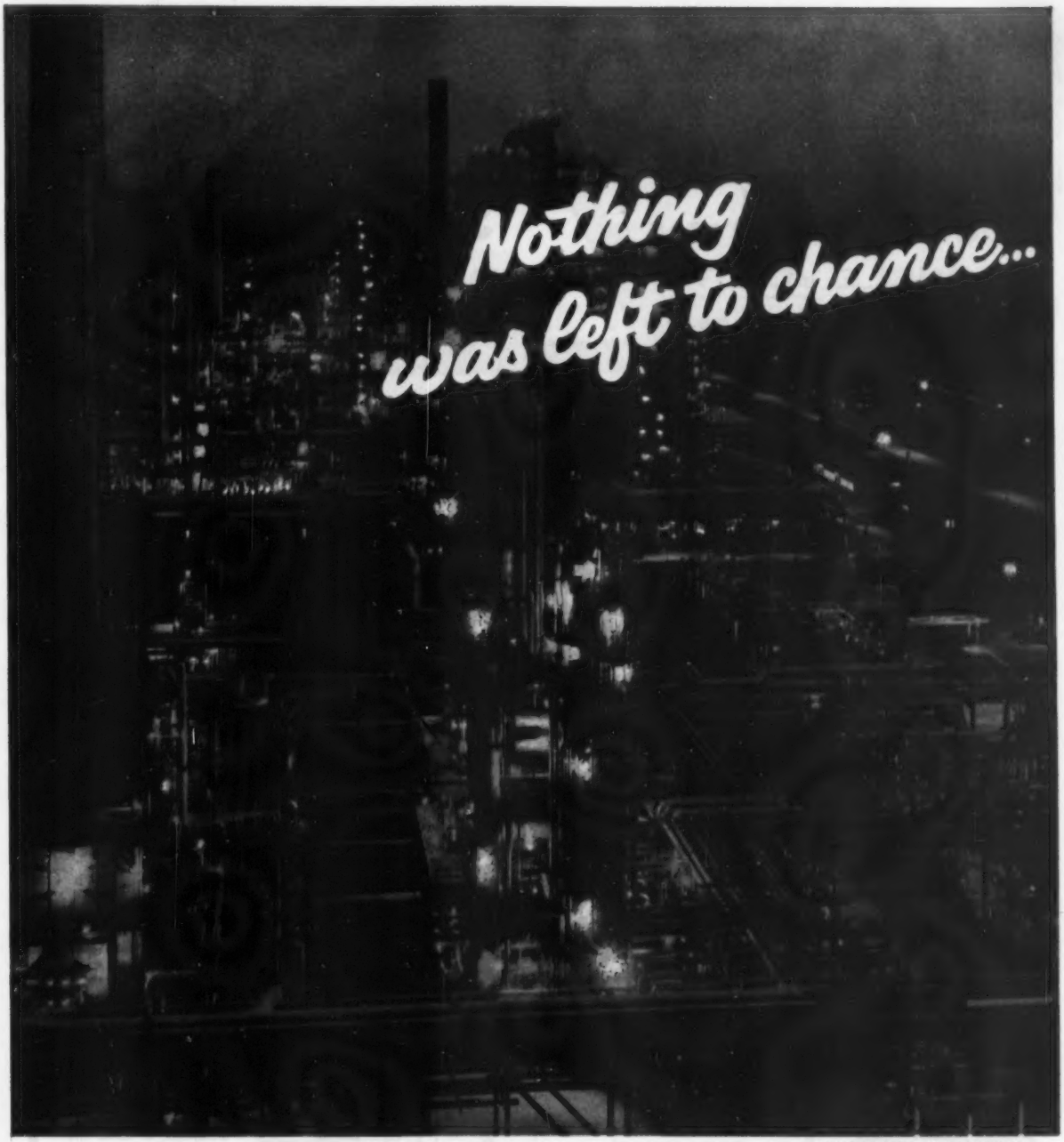


PHOTO COURTESY OF C F BRAUN & CO
ENGINEERS AND CONSTRUCTORS

PACIFIC PUMPS INC was selected to supply practically 100% of TIDEWATER'S centrifugal process pumps for their new DELAWARE REFINERY

Pacific's world-wide reputation for engineering pumps with outstanding performance and service records was further evidenced by Tidewater's choice. We are justly proud of this opportunity to put more Pacific pumps to work for Tidewater at Delaware as we have at their Avon, California refinery. It is our feeling that our excellent pump service engineering staff (always available when needed, anywhere, anytime) also influenced their decision. Whatever your pumping requirements—it will pay you to consult Pacific.

PACIFIC

PACIFIC PUMPS INC.

HUNTINGTON PARK, CALIFORNIA

Offices in all Principal Cities

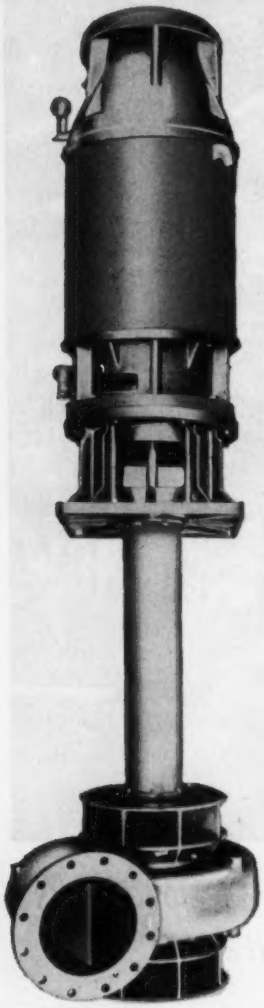
CP-17

For more data on advertised products, use Readers' Service Cards, last page.

Bingham

TYPE "VS" DOUBLE SUCTION DOUBLE VOLUTE VERTICAL PUMP

REDUCES COSTS WITH SHALLOW PIT LOWER MAINTENANCE



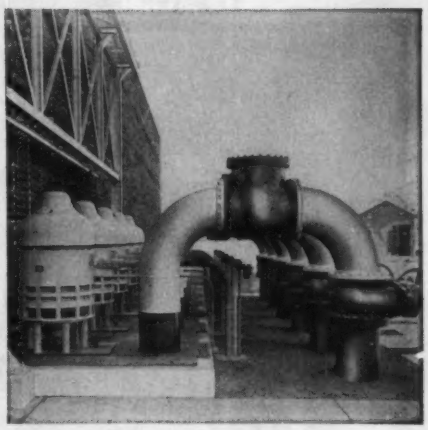
SPECIALLY DESIGNED FOR WET-PIT SERVICES. COOLING TOWER, SPRAY POND, DISPOSAL SUMP, WATER SUPPLY, DRAINAGE — AND OTHER HIGH-CAPACITY, MEDIUM-HEAD WET-PIT SERVICES.

The BINGHAM "VS" Pump, which is an advanced design of a "Double Volute"—"Double Suction" single stage pump, saves money in three ways: (1) Lower installed cost because it does not require a deep pit and can use standard motors. (2) Lower operating cost, because it operates at higher efficiencies, uses less power. (3) Lower maintenance cost, because there is no stuffingbox, all bearing loads are light, and the installation is easy to inspect and service.

The "Double Volute" construction of the "VS" Pump maintains radial balance of its rotating element throughout the entire operating range of the pump. Wear due to "Side Push" is eliminated.

The "Double Suction" feature of this pump eliminates axial hydraulic thrust, thereby permitting the use of standard vertical motors.

These and many other important reasons make the BINGHAM "VS" Pump the most logical choice today for wet pit service. For full details call your nearest Bingham Office or write for Bulletin No. 110.

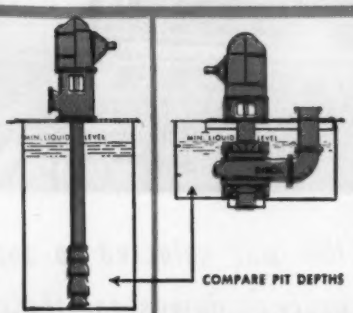


A Battery of Bingham "VS" Pumps Operating at a major Gulf Coast gas processing plant.

COMPARE THESE PITS FOR COST

OLD

Conventional Deep-Well Turbine Pump Installation . . . requires the pit be deep enough to maintain sufficient pumpage above the pumping element in order to provide the required NPSH.



NEW

Bingham "VS" Pump Installation . . . requires only a shallow pit and only sufficient pumpage to cover the pumping elements. Pit construction is thereby *greatly reduced.*

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY

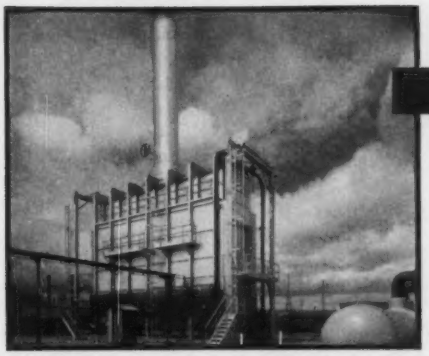
General Offices: **2800 N.W. Front Avenue, Portland 10, Oregon**

Factories: **Portland, Ore. • Vancouver, B. C., Canada**

SALES AND SERVICE OFFICES

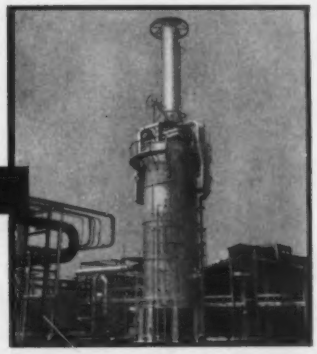
BOSTON, MASS.
CHICAGO, ILL.
CLEVELAND, OHIO
DALLAS, TEXAS
DENVER, COLO.
HOUSTON, TEXAS
KANSAS CITY, MO.
LOS ANGELES, CALIF.
NEW ORLEANS, LA.
NEW YORK CITY, N.Y.
PHILADELPHIA, PA.
PITTSBURGH, PA.
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
ST. LOUIS, MO.
ST. PAUL, MINN.
TULSA, OKLA.
TORONTO, ONT., CAN.
VANCOUVER, B. C., CAN.

NOW A BORN HEATER for every process heating requirement



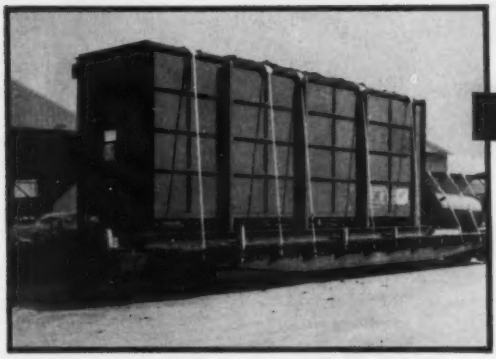
BORN "UPFLO" HEATERS

A horizontal tube heater for highest fuel efficiencies and even heat distribution.



BORN "VERTIFLO" HEATERS

A vertical tube heater for use where space is critical.



BORN "PREFAB" HEATERS

Rugged and versatile these units are shipped completely assembled and skid-mounted, eliminating field construction. Available either with HORIZONTAL tubes or VERTICAL tubes.

BORN "PARIFLO" HEATERS

Suspended tube design for ultra high temperatures and close zone control.

BORN HEATERS are especially designed for your heating requirements. Contact your nearest BORN representative for complete information.

BORN Engineering Company

Manufacturers of Direct-Fired "UPFLO" Heaters

TULSA, OKLAHOMA

BRANCH OFFICES:
Denver, Colo.; Houston, Tex.; Los Angeles, Calif.; New York, N. Y.; Shreveport, La.

FOREIGN OFFICES:
Canadian Bronze Steel Tank Co., Ltd.
Brandon, Manitoba, Canada
Brander & Cia. S. A.
Tacuari 318
Buenos Aires, Argentina
Promotinco
30 Boulevard Gouvion St. Cyr
Paris 17, France

For more data on advertised products, use Readers' Service Cards, last page.

Only COMMERCIAL gives you one-man control

for heavy-duty metering . . .

Commercial Type CS Orifice Fittings are specially engineered for controlled metering on large diameter gas and oil transmission lines. These giant fittings are over eight feet tall and weigh five tons. Yet one man can easily and safely swing the upper chamber aside by turning the large handwheel, or can lower the heavy orifice disc to pipe line level by operating the two-speed elevator gear box.

Body construction conforms with ASA, ASME and ASTM design requirements. The ASA 600-lb. pressure rating adapted to the fittings shown, requires operating pressures up to 1440 psi and results in body loads greater than 1,400 tons . . . a good reason for sound design!

Five types of Commercial Orifice Fittings are available, each with a specific application for your metering requirements in sizes from 2" to 30", pressure ratings 125 to 2500-lb. ASA. For further details see your Composite or Refinery Catalog, or write . . .

Commercial Type CS 30", 600-lb. ASA Orifice Fitting installed at El Paso Natural Gas Co. gasoline plant at Blanco, New Mexico.

Operation or inspection is simple, one-man job.

COMMERCIAL IRON WORKS

2424 Porter Street, Los Angeles 21, California

1957—OUR 52ND YEAR SERVING INDUSTRY

For more data on advertised products, use Readers' Service Cards, last page.

Employment Office for HEAT...

Do you have a source of waste heat... from still bottoms, intermediate fractions, process liquids, or exhaust steam... that is not being put to useful work?

If so, refer the matter to the G-R Employment Office For Heat. This "employment agency" has found well-paying jobs for waste heat in refineries all over the country... to preheat incoming fluids, to heat other liquids, air, or gases, and to generate steam. G-R heat exchanger designs have successfully recovered heat even from tarry and dirty materials that have clogged previously used units, and they are materially reducing fuel costs and improving plant processes in many hundreds of refineries.

Your inquiry will receive prompt attention from the G-R engineers who have long specialized in solving heat-transfer problems of every conceivable kind. Write for advice and specific recommendations on *your* waste heat problem.

THE GRISCOM-RUSSELL COMPANY

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

MASSILLON, OHIO

Griscom-Russell

HEAT TRANSFER APPARATUS

GR-371

"Can you furnish an efficient heat exchanger for 2 fluids of different transfer rates?"

"I need a stock design of heat exchanger for quick shipment."

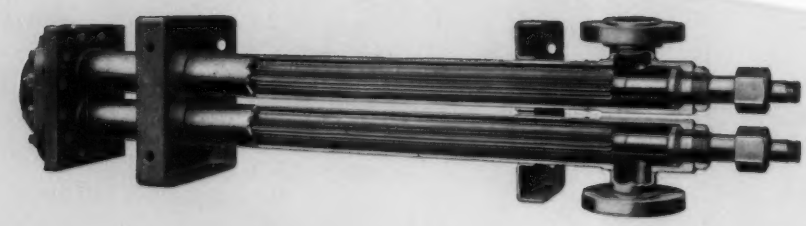
"Is it possible to get a heat exchanger with fins and tubes of different materials?"

"Do you have a standardized heat exchanger that can be used for a variety of services?"

"I want a heater system that will require least spare units."

FIVE QUESTIONS
One Answer...

THE G-R TWIN G-FIN SECTION



Yes, this "Universal Heat Exchanger" meets all these needs . . . and many more. It actually has the widest range of heating, cooling, condensing and heat exchange applications of any heat transfer apparatus on the market. • The G-R Twin G-Fin Section has proved its effective design and durable construction through 25 years of service. • This unit is the simplest type of heat exchanger, easy to install, economical to maintain, and with high salvage value because of its standardized design. Write for bulletin describing the many Twin G-Fin Section advantages in detail.

THE GRISCOM-RUSSELL CO.

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

MASSILLON, OHIO

GR-974

Newalls

OFFER COMPLETE TECHNICAL SERVICE

NEWALLS are constantly expanding the scope of their technical service. Founded on 50 years of success in industrial insulation on land and sea they provide expert guidance on refinery insulation all over the world.

Newalls cover much more than the supply of first-class insulating materials. From plant conception to installation, and afterwards, Newalls offer a complete service on insulation problems. Our technical staff are ready to handle the specifications and estimation work for any type of plant, large or small, and provide skilled supervision on site.

Calling in our technical service ensures optimum performance.

Newalls insulation materials are in service on the following refineries:

AUSTRALIA
Altona
Kurnell
Kwinana

BELGIUM
Albatros Extensions, Antwerp,
C.B.P. (Compagnie Belge de Petroles)
Esso, Antwerp,
Petrofina, Antwerp

BRAZIL
Cubatao

FRANCE
Berre
Donges
Du Nord (Dunkirk)
Gonfreville
Lavera
Petite Couronne
Port Jerome

INDIA
Stanvac, Bombay

MIDDLE EAST
Abadan
Aden
Bahrain
Haifa
Kuwait
Ras Tanura

VENEZUELA
Amuay
Cardon

Newalls

TECHNICAL ADVISORY SERVICE

NEWALLS INSULATION CO. LTD.,
WASHINGTON, CO. DURHAM, ENGLAND
A member of the TURNER & NEWALL ORGANISATION
Agents and Vendors in most world markets

For more data on advertised products, use Readers' Service Cards, last page.

Refinery Insulation

All CAPOSITE moulded insulation materials are made of Amosite asbestos. The photograph clearly demonstrates the immense volume which is obtained when the natural Amosite is fiberised—the sign of high efficiency as an insulating medium.

CAPOSITE is supremely well suited to the thermal insulation of oil refineries. With a limiting temperature of 1000°F., high thermal efficiency and great structural strength and resilience, CAPOSITE has gained for itself a unique position among thermal insulation materials used by the Oil Industry.

CAPOSITE MOULDED ASBESTOS FIBRE PIPE INSULATION

EFFICIENCY DATA SHEET—PIPE SIZES 6" to 10" BORE.

HOT FACE TEMPERATURE °F.			400°F			600°F			800°F		
THERMAL CONDUCTIVITY K=B.Th.U. in./sq. ft./hr./in./°F.			0.43			0.47			0.53		
MEAN TEMPERATURE °F.			250			350			450		
Nominal Pipe Size	O.D. pipe	Thickness of Insulation	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.
6"	6¼"	1"	135	87·7	126	233	90·6	167	354	92·5	218
		1½"	102	90·8	107	177	92·9	135	270	94·3	171
		2"	83·6	92·4	97	145	94·1	118	223	95·3	145
		2½"	71·8	93·5	91	125	95·0	107	192	96·0	128
		3"	63·5	94·2	86	110	95·5	100	170	96·4	117
		3½"	57·3	94·8	83	100	96·0	95	154	96·7	109
		4"	52·6	95·2	81	91·7	96·3	91	142	97·0	103
8"	8⅝"	1"	130	88·0	127	225	90·8	169	341	92·7	222
		1½"	97·7	91·0	108	169	93·1	137	258	94·5	174
		2"	79·2	92·7	98	138	94·4	120	211	95·5	148
		2½"	67·4	93·8	92	117	95·2	109	180	96·1	131
		3"	59·2	94·6	87	103	95·8	102	159	96·6	120
		3½"	53·2	95·1	84	92·7	96·2	96	143	96·9	111
		4"	48·5	95·6	82	84·6	96·5	92	131	97·2	105

These figures are compiled from results of official tests by THE NATIONAL PHYSICAL LABORATORY, TEDDINGTON, computed in accordance with formulae shown in BRITISH STANDARD SPECIFICATION appendices.

Please write for full technical details

THE CAPE ASBESTOS COMPANY LIMITED

114 & 116 Park Street, London, W.1.

Cables: Incorrupt, London.

CAPOSITE REGD

Amosite Asbestos Blocks and Pipe Sections

Enquiries in CANADA to: Cape Asbestos (Canada) Ltd., 200 Bloor Street East, Toronto, Ont.
U.S.A.: The North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.
SOUTH AFRICA: Cape Asbestos South Africa (Pty.) Ltd., P. O. Box 2533, Johannesburg; ITALY: Capamianto S.P.A., via Sant' Antonio 57, Turin. FRANCE: Isolamiante S.A. 37 Avenue Franklin D. Roosevelt, Paris 8e.

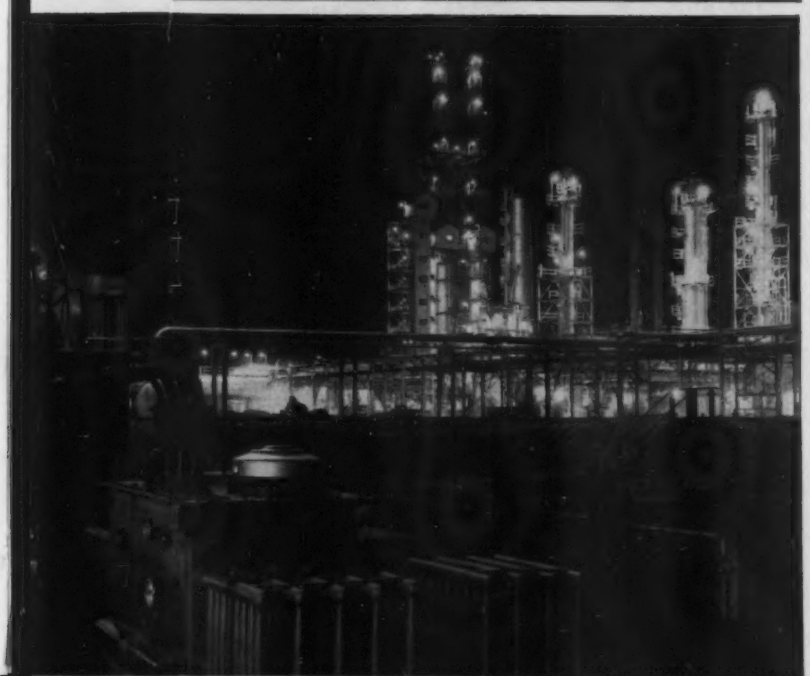
CAPE

To protect process growth . . .

Take a new look at electrical system dependability

These chemical and petroleum companies did . . . and found new advantages in Westinghouse distribution equipment and engineering counsel.

American Cyanamid and Westinghouse Engineers worked out a power distribution system that prevents outages. If there's trouble on any feeder, power is switched to another. If a substation faults, other substations carry the load through cross connections. This system can be easily and inexpensively expanded as the plant grows.



Sohio's Lima Refinery achieves power dependability without paying extra for stand-by capacity. In a period of over two years, this Westinghouse equipped system handled power interruptions without loss of refinery production.

Get economy with system protection →

YOU CAN BE SURE . . . IF IT'S

Westinghouse

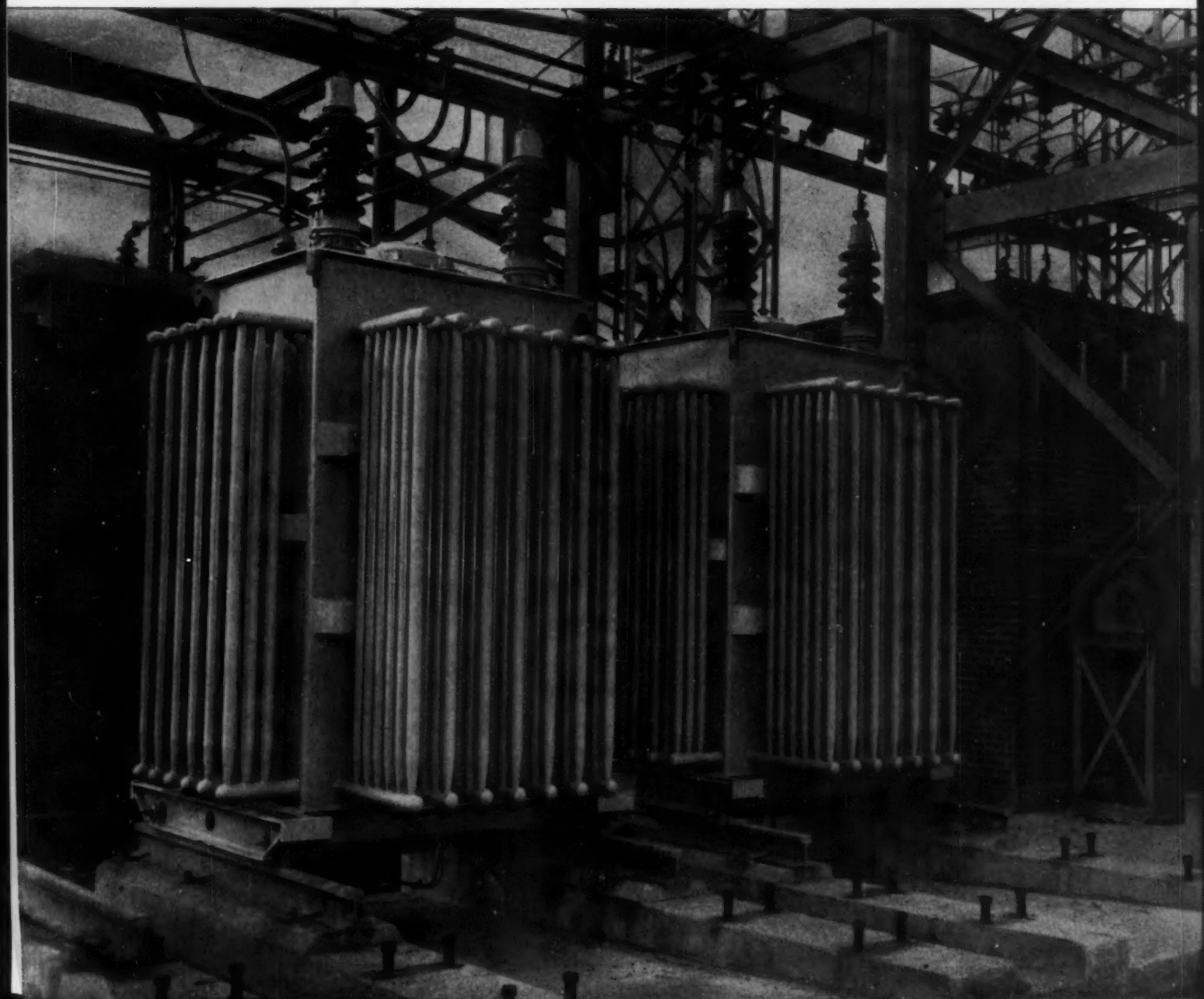
Call Westinghouse early to . . .

coordinate equipment for low cost, power dependability

Early planning of your power distribution system is the only effective way to answer these basic questions:

1. **How can I get the most reliability for dollars spent?**
2. **Will my electrical system be adaptable to changing load conditions with minimum service interruptions?**
3. **Can I get good voltage regulation in spite of load fluctuations?**

1. Standardized type SL transformers — liquid filled substation transformers for chemical use offer the many economies of Westinghouse standardization and design advantages based on years of tested and proved experience.



The choice of types of equipment and power distribution layout will depend on the problems in your plant . . . change-over, expansion, modernization, new processes or products. Westinghouse can help you select the right equipment and coordinate it to bring out the specific advantages that best suit your requirements.

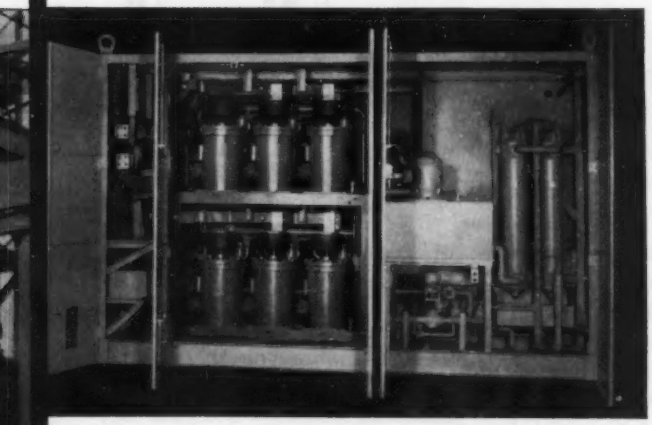
Here are brief descriptions of the advantages you'll find in Westinghouse apparatus for a proven distribution system. They suggest many ways to provide maximum reliability without the expense of standby facilities.

Discuss your plans with your Westinghouse Sales Engineer, or write: Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

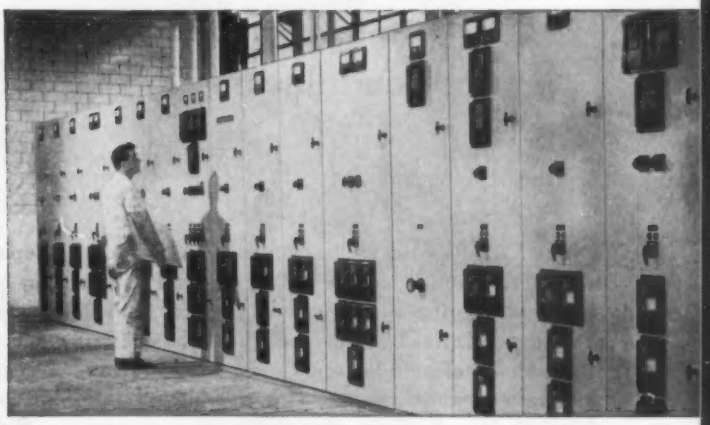
MP-3054

YOU CAN BE SURE...IF IT'S Westinghouse

2. Westinghouse oil circuit breakers with automatic reclosing equipment can automatically restore service to protect incoming lines or feeder circuits from prolonged and costly outages.

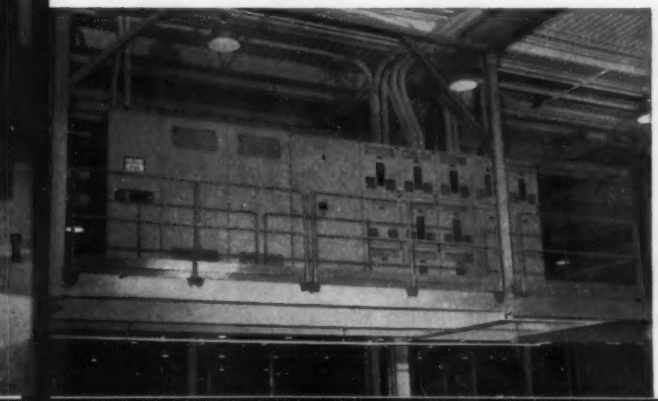


3. High availability and low maintenance of Westinghouse Ignitron Rectifiers has resulted in electrochemical installations totaling millions of kilowatts. Units are completely metal enclosed and factory assembled for low installation cost, minimum floor space.

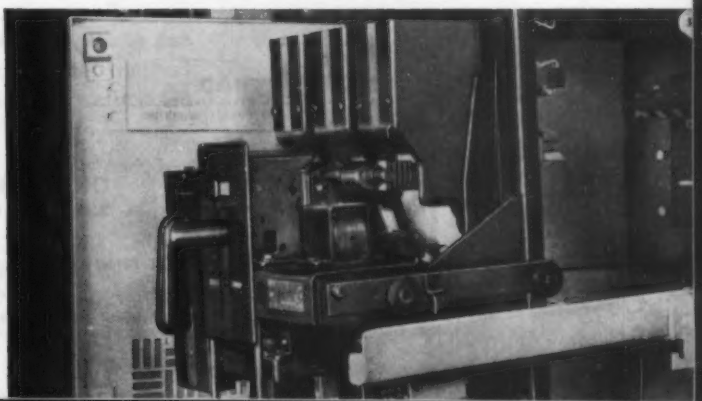


4. Westinghouse Metal-Clad High Voltage Switchgear provides unusual safety through interlocking devices and full steel barriers in a completely compartmentalized design.

5. Westinghouse unitized dry-type power centers solve the problem of handling increased power loads economically. They cost less to install because they do not require expensive enclosures and can be located close to the center of the load. For expansion, install additional breakers in spare feeder compartments.



6. Westinghouse low-voltage switchgear design provides an unusual degree of flexibility. This results from modern selective tripping. You get perfect coordination of time-delay characteristics, which confines outages to the faulted section alone.



STOP!

SULFIDE-SCALE FORMATION IN REFORMING UNITS!

with Alumi-Spra*

This PROVEN aluminum coating *not affected by* H_2-H_2S in furnace tubes and feed lines.

SULFIDE-SCALE formation in reforming units has been a king-size headache for oil refineries. In some cases, it has been necessary to chemically clean tubes and transfer lines every few months. This is costly. It hikes maintenance costs, replacement costs, and most importantly, *cuts production, thus depriving oil companies of valuable income!* No wonder everyone is trying to prolong the effective life of these vital tubes.

Here at last is a proven answer to the problem. Chicago Metallizing Corporation's new ALUMI-SPRA is a positive way to prevent corrosion due to sulfide scale. The new ALUMI-SPRA process actually makes an aluminum-clad tube out of your standard furnace or feed line tubing. Aluminum is deposited uniformly and with a firm bond to prevent any tendency toward spot breaks in the coating which would allow corrosion to form locally and spread. Thus, on-line service duration is increased two- or three-fold over that of ordinary steel tubing, without the formation of sulfide scale. Thus, good heat transfer is maintained, allowing furnaces to be operated at normal design temperatures.

And the cost of ALUMI-SPRA is reasonable too. This, plus the fact that down-time is cut in half, makes ALUMI-SPRA the most reasonable kind of corrosion protection you can get. Write or call us today for further details and study of your particular problems.

SEND FOR COMPLETE FACT FILE—We can furnish complete literature and specifications to enable you to consider ALUMI-SPRA in light of your particular situation. For your fact file, write Chicago Metallizing Co., 3321 South Pulaski Road, Chicago 23, Illinois. Do it today!

Alumi-Spra*

CHICAGO METALLIZING CORPORATION
3321 South Pulaski Rd. • Chicago 23, Illinois
Phone Virginia 7-7535

*U.S. Patent Applied For

3 WAYS TO MEASURE TEMPERATURE

bi-metal

THERMOMETERS

for industrial and "built-in" needs

Overwhelmingly preferred because of their all-metal ruggedness, stability and long life. In heavy duty types, straight and angle forms, 6" and 5" dia heads – industrial types, angle form, 3" and 2" heads; stainless steel stems, lengths from 2½" to 24". Ranges low as –100 F to high as 1000 F; accuracy 1% of range.

filled system

THERMOMETERS

for remote readings—alarms

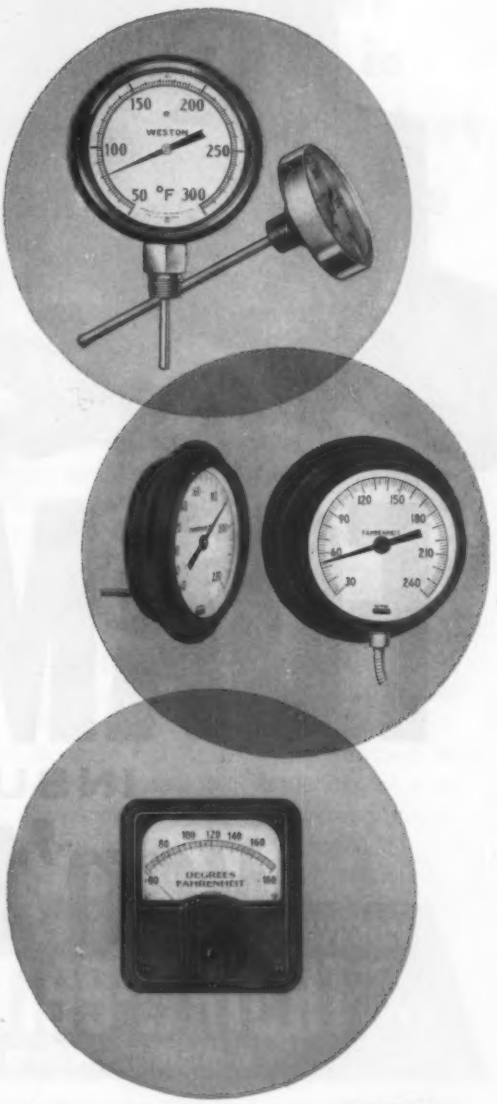
Available with mercury, liquid, gas filled, or vapor pressure actuations in 5", 6" and 8" dial sizes – for wall or flush mounting. Models to indicate as low as –325 F or as high as 1000 F. Available with adjustable electrical contact and index pointer for signal or alarm needs.

electrical resistance

THERMOMETERS

for remote and multiple readings

Resistor bulb permits remote temperature readings – and by use of several bulbs, several different remote temperature measurements can be made using a selector switch. Accuracy 1% of full scale. Ranges low as –100 to high as 500 F.



For literature write . . . Weston Electrical Instrument Corp., Newark 12, N. J.

WESTON THERMOMETERS

For more data on advertised products, use Readers' Service Cards, last page.

Some insulations feed a fire . . .

FOAMGLAS®

INSULATION won't burn!

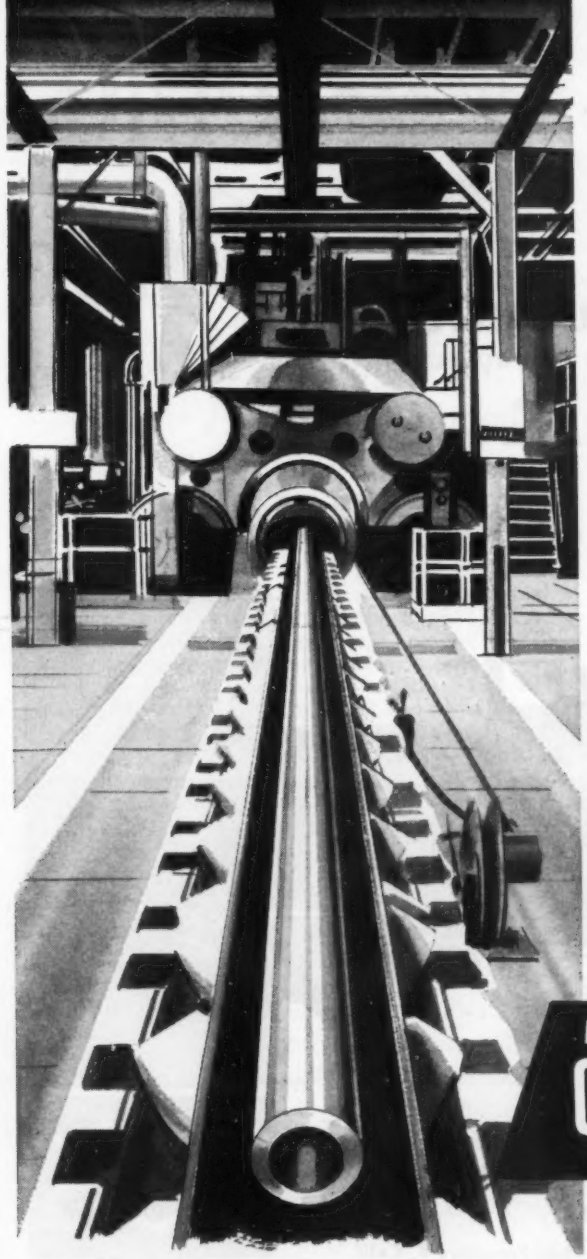
—and only inorganic FOAMGLAS insulation offers all these added benefits . . . waterproof and vapor-proof (closed glass cell structure) . . . dimensionally stable . . . high compressive strength . . . vermin-proof . . . easy, economical to handle and install. Write for detailed literature.

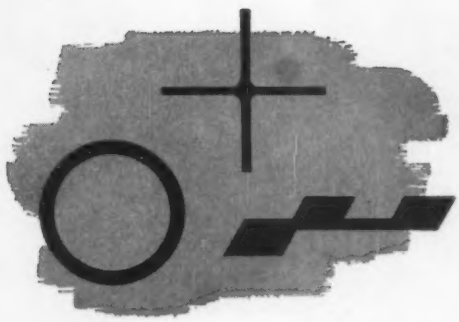
FOAMGLAS is listed by Underwriters' Laboratories, Inc. under Label Service.

PC PITTSBURGH CORNING®

Pittsburgh Corning Corporation
Dept. Z-97, One Gateway Center, Pittsburgh 22, Pa.
In Canada: 57 Bloor Street West, Toronto, Ontario

Shaping a new future for Industry





CURTISS-WRIGHT extrudes steels in shapes, lengths and sizes never before possible

Curtiss-Wright's Metals Processing Division is pushing steels into new uses for all industries. Shapes and sizes never before possible are being extruded in constantly increasing tonnages from alloy steels, stainless, titanium and other metals.

Starting with billets weighing up to 9000 pounds, the world's largest horizontal steel extrusion press moves the metal into shapes of virtually any profile that can be circumscribed by a 20-inch circle. Or, in a matter of seconds, the raw material may become heavy wall tubing up to 22 inches in diameter.

The 12,000 ton extrusion press and the complete facilities of Curtiss-Wright's Metals Processing Division are ready to go to work for you . . . to advance the design and production of metal products beyond the limitations of conventional equipment. Qualified engineering consultation available at all branch offices.

70 Grider Street

METALS PROCESSING DIVISION
CURTISS-WRIGHT
CORPORATION • BUFFALO, N. Y.

Metals Processing Division Branch Offices:
New York • Houston • Los Angeles

ELECTRONICS • NUCLEONICS • PLASTICS • METALLURGY • ULTRASONICS • AVIATION

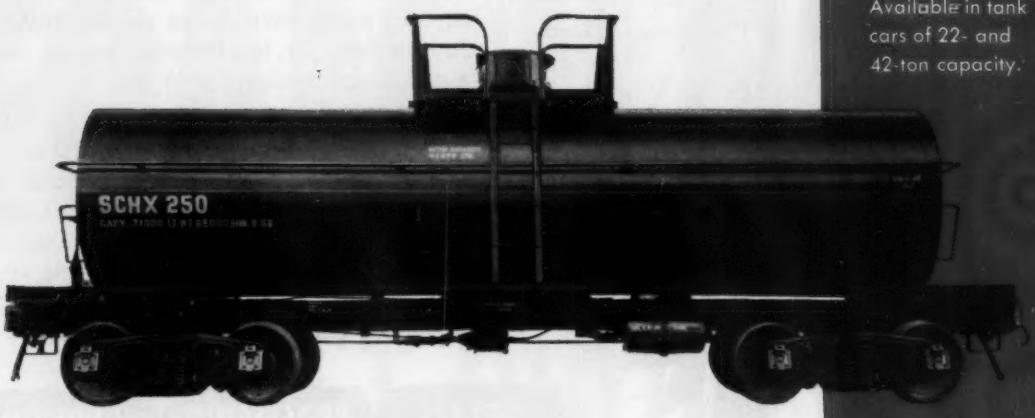
For more data on advertised products, use Readers' Service Cards, last page.

HF

HYDROFLUORIC ACID

anhydrous and aqueous

STAUFFER HAS IT...
IN QUANTITY AND QUALITY



Available in tank cars of 22- and 42-ton capacity.

STAUFFER CHEMICAL COMPANY

380 Madison Avenue, New York 17, N.Y.

Prudential Plaza, Chicago 1, Ill. • 636 California Street, San Francisco 8, Calif.

NYOTEX CHEMICAL DIVISION, P.O. Box 9716, Houston 15, Tex.

Stauffer CHEMICALS SINCE 1885

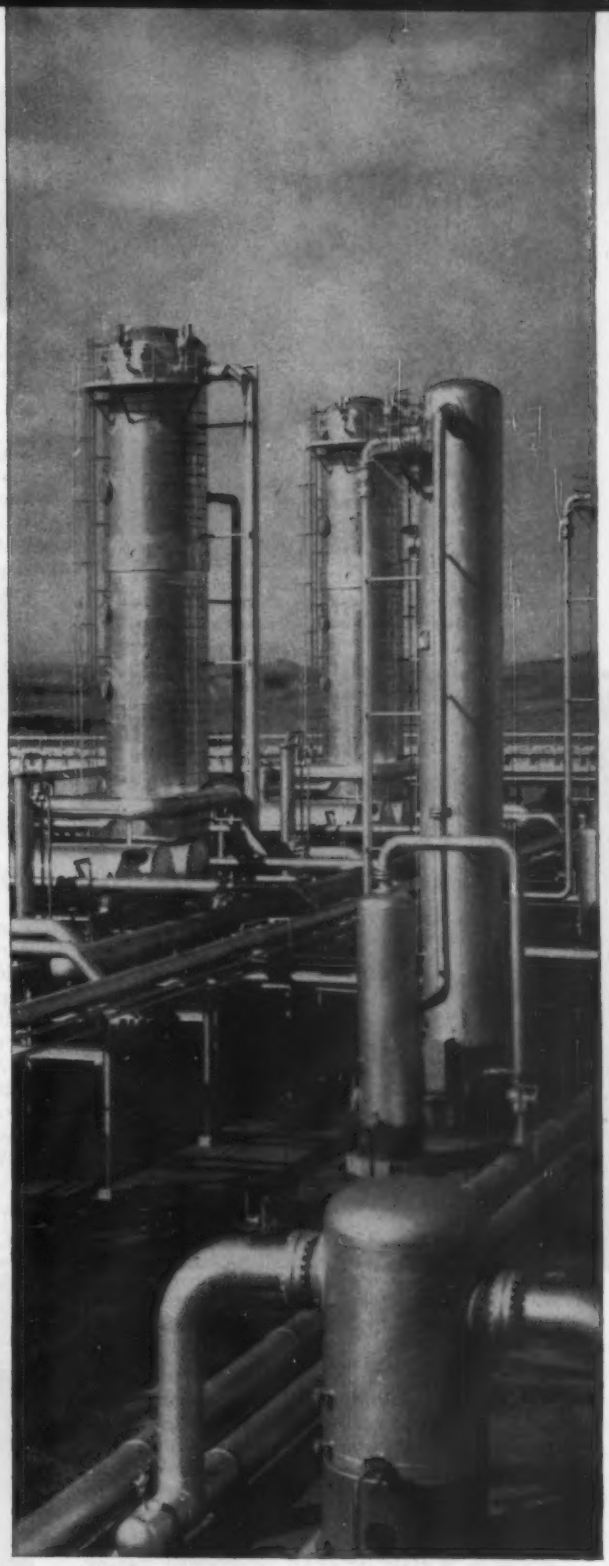
Performance-proved CURE for CORROSION HEADACHES

Specify Alcoa Aluminum for
• Process Equipment
• Transfer and Storage
• Plant Structures

Excessive maintenance and replacement of materials and equipment has fast become the biggest single headache in the process industries. Corrosion is far and away the most serious cause of such headaches. That's the big reason why aluminum—Alcoa® Aluminum—is daily being specified and installed in an increasing variety of uses throughout the process industries.

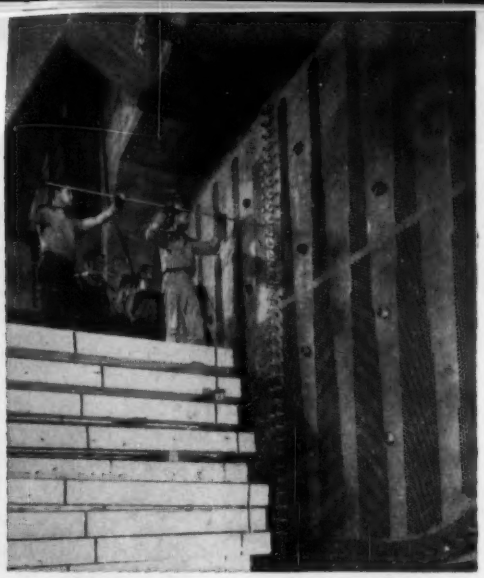
No other metal can match the ability of aluminum to resist successfully so many types of corrosive attack. And aluminum can be used to bring that unmatched corrosion resistance to a variety of applications . . . because only aluminum combines these *other* valuable properties in a single metal:

Light weight
Good workability
High thermal and electrical conductivity
Great strength in alloys
Nonmagnetic, nonsparking characteristics
Nontoxicity
Good reflectivity
Clean, attractive appearance
Low cost

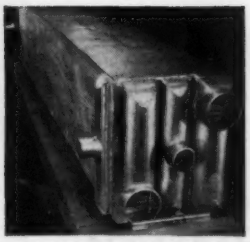


Study the next three pages to discover a few of the many process industries' uses of Alcoa Aluminum which insure outstanding metal performance . . . unhampered by corrosion. See why these various uses of aluminum have already helped hundreds of others . . . and can help you!

ALUMINUM COMPANY OF AMERICA



This brazed aluminum assembly, weighing nearly 900 pounds, is typical of exchangers used in air separation plants and other low-temperature exchange processes.



A 105,000 sq ft surface condenser with Alcoa aluminum heat exchanger tubes.

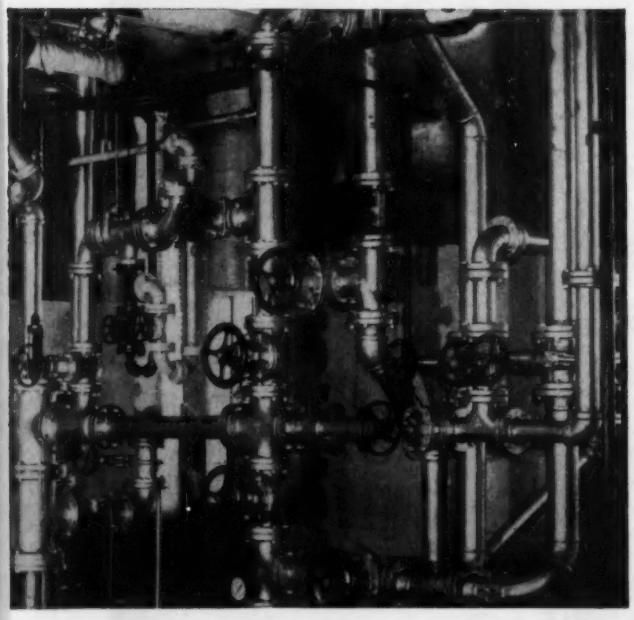
heat exchanger tubes

Aluminum heat exchanger tubes are low in cost, resist oxidation and other chemical attack, are easy to fabricate, have excellent thermal conductivity and freedom from embrittlement at low temperatures.

Aluminum tubes have demonstrated their ability to give long, dependable service under severe conditions. They are used extensively in exchangers for handling hydrogen peroxide, nitric acid, hydrogen sulfide, ammonia, naval stores, glycerine, scrylonitrile and other chemicals. Alclad tubes are recommended for use with natural cooling waters.

Aluminum costs approximately ½ the cost of admiralty, less than ⅓ the cost of stainless, and in the common ¾" and 1" sizes, less than mild steel.

Get detailed information on Alcoa aluminum heat exchanger tubes in booklet AD186, available on request.



process piping

Corrosion resistant Alcoa aluminum pipe is widely used to carry liquids and gases in chemical, petrochemical, petroleum and food processing plants. It resists attack by the materials carried as well as by the corrosive atmosphere often encountered around such plants. And it prevents product contamination or discoloration.

Aluminum pipe is available in all of the normally produced schedules. It is by far the lowest priced corrosion resistant pipe available. For example, schedule 40 aluminum pipe is ¼ the cost of schedule 5 stainless, 1/7 the cost of schedule 40 stainless.

Write for *Aluminum Pipe and Fittings* booklet, AD197.

◀ Alcoa aluminum pipe proved ideal to solve corrosion and product contamination problems in this processing plant.

unitrace*

Alcoa now offers a new and improved design of Unitrace, the unique aluminum steam-traced pipe which incorporates the steam line as an integral part of the pipe. Extruded as a single unit of aluminum, from Alcoa 3003-F alloy, Unitrace is available in diameters equal to 1½", 2", 3" and 4" pipe.

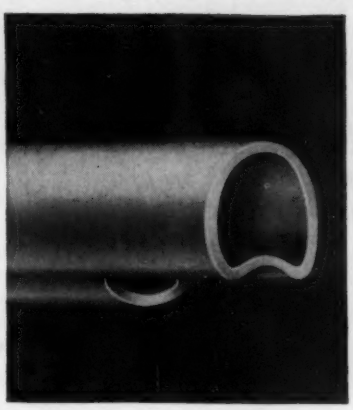
Special cast Unitrace flanges and fittings are available in alloy A356-T6 for efficient joining of sections. In many installations, flanging is not required, as sections of Unitrace can be joined easily by welding.

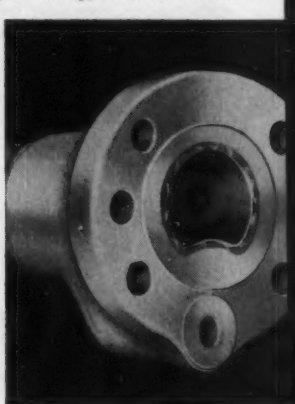
Preformed insulation will fit Unitrace although thermal insulation is unnecessary in many cases.

For detailed information, write for Bulletin AD418.

*Registered trademark

New type Unitrace section showing trace line cut back for joint. (Right) Special cast Unitrace flange for easy, efficient joining of new type Unitrace sections.





ALUMINUM COMPANY OF AMERICA

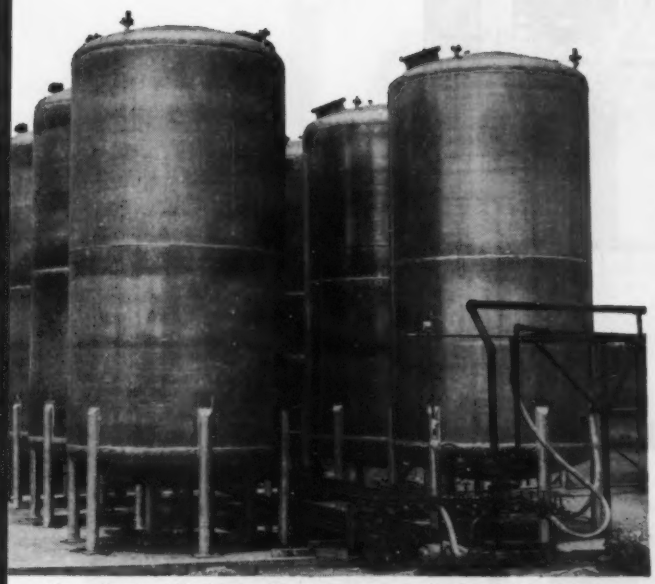
World's largest all-aluminum tank stands 26 feet high, has a diameter of 128 feet, holds 2½ million gallons of 83% ammonium nitrate solution.

standard and special storage tanks

Alcoa standard storage tanks, fabricated of 3003 alloy, are supplied in sizes ranging from 5,800 to 21,400 gallons. Both horizontal and vertical construction are available.

Made from stocked components, these standard tanks bring the user all the advantages of Alcoa Aluminum at lower cost, with faster delivery.

Storage tanks to meet many special requirements may be constructed of Alcoa sheet and plate. Information on design and fabrication will be furnished on request. Write for *Alcoa Standard Storage Tanks* Bulletin, AD387.



Alcoa Standard Tanks provide storage economies for a wide variety of chemicals.

shipping containers

Alcoa offers a wide variety of shipping containers conforming to ICC regulations. Ranging in size from 7½ to 110 gallons, they are used to ship such diverse products as beer and fuming nitric acid.

Alcoa aluminum containers are lighter in weight than containers of other suitable materials, are less expensive and give longer service.

roofing, siding, structurals and paint

Alcoa industrial building sheet is used for roofing and siding on plant buildings and to protect conveyors and other outdoor equipment. The aluminum surface requires practically no maintenance and lasts well even when exposed to corrosive atmospheres often encountered around processing areas. It is easily installed and helps to keep construction costs low.

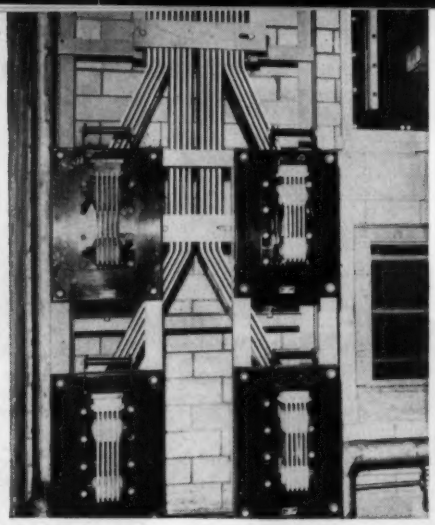
Alcoa also supplies structural shapes for use in construction where their corrosion resistance and consequent low maintenance cost are advantageous.

Paints pigmented with Alcoa Aluminum provide a continuous metallic sheet of pure aluminum for unmatched protective power.

Write for *Alcoa Industrial Building Products* booklet, AD285, *Alcoa Sandwich Walls* booklet, AD625, or *Painting With Aluminum* booklet, AD228.

Aluminum exterior surfaces for buildings and conveyors provide pleasing appearance with minimum maintenance.

ALUMINUM COMPANY OF AMERICA



bus bars

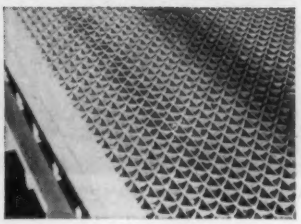
Lowest cost per unit current capacity and good corrosion resistance are key advantages for aluminum bus bars in process plants. Write for Alcoa Bus Conductor Handbook, AD661.

grating and tread plate

New grating-type Alcoa aluminum stair treads require no paint . . . are available in all standard sizes at a price competitive with galvanized steel and abrasive nosing. (Write for Bulletin AD679.)

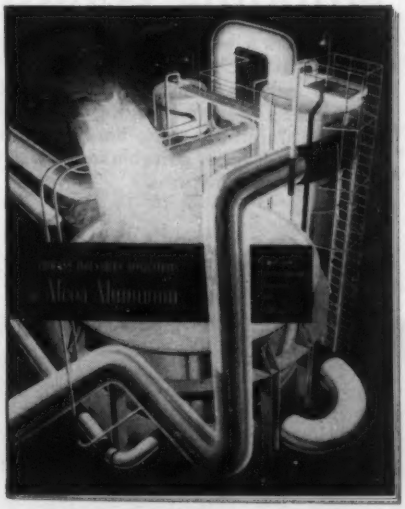
Aluminum grating is used widely for floors and walkways in and around processing plants because of its light weight, resistance to corrosion, low maintenance and nonsparking characteristics.

Alcoa supplies both a standard aluminum tread plate and Alcoa Abrasive Tread Plate. The latter has a self-renewing, bonded abrasive surface for extra nonskid protection. (Write for Bulletin AD596.)



this free book

. . . can be your dependable guide to solving corrosion problems in the process industries. Send for it now. Its 80 pages are filled with definitive data on the behavior of aluminum with specific materials . . . along with detailed design and specification information. Your copy will be sent promptly. Ask for Process Industries Book, AD460.



use Alcoa engineering assistance to solve your corrosion problems

In the course of many years' study of corrosion problems, Alcoa has acquired an immense fund of practical, nonconfidential information on corrosion characteristics of many materials and processes under various conditions. This information is available to you without obligation. Simply write Alcoa.

To insure receiving the most useful information, state your problem as specifically as possible. Alcoa's development engineers will then supply and help you evaluate the best available information.

Alcoa is also prepared to undertake cooperative testing programs in certain cases where existing data is insufficient. Contact your nearest Alcoa sales office for details.

Aluminum Company of America
905-J Alcoa Building, Pittsburgh 19, Pa.
Please send me the following literature (see above for booklet nos.):

_____

_____

_____

Name_____

Company_____ Title_____

Address_____

City_____ Zone____ State_____

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

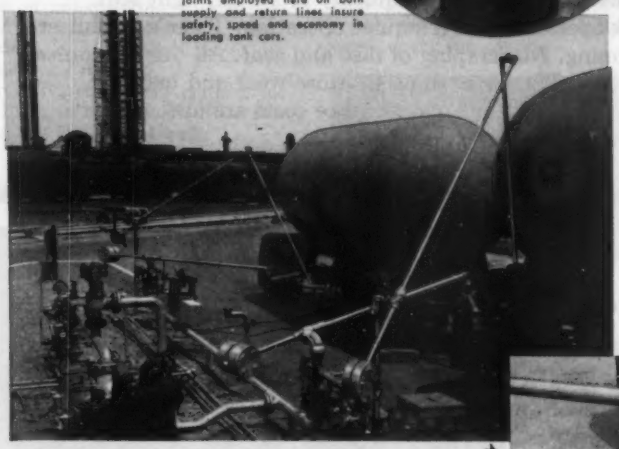
THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

When Butane says "HANDLE WITH CARE"

CHIKSAN ADDS SAFETY and SPEED TO LOADING OF TANK CAR AND TRUCK

With counterbalanced Chiksan loading racks, one man can quickly and easily make connections to tank cars.

CHIKSAN low pressure swivel joints employed here on both supply and return lines insure safety, speed and economy in loading tank cars.



A typical near ground level truck loading rack using CHIKSAN joints on supply and return lines.

Close up of CHIKSAN low pressure joints on supply and return lines in truck loading of Butane.

It takes speed, safety and kid-glove handling to keep up the massive flow of liquefied petroleum gas at Standard Oil Company of California's El Segundo plant.

Chiksan provides the necessary liquid-tight, gas-tight unions, the characteristic flexibility of motion to keep the touchy Butane flowing at a swift, even pace with safety to workers, plant and community — with profit to the company.

No less than eight Chiksan Ball-Bearing Swivel Joints are needed for each loading installation to keep the gas moving into tank and truck—to provide the essential carry-off of the highly explosive vapors. And with Chiksan on the job, metal of relative low porosity takes the place of more porous and less safe rubber.

Standard Oil Company of California's El Segundo installations are typical of industry's reliance on Chiksan Ball-Bearing Swivel Joints around the world to speed the flow of enterprise — to promote production and defense—to increase safety—to protect profits.

Wherever liquid or gas must flow in industry—wherever hydraulic systems can add efficiency and economy—Chiksan Ball-Bearing Swivel Joints are on the job. If more flexibility—greater stamina—longer life and added economy are of interest to you, Chiksan's Research and Development Division can help you find a better, swifter way.

CHIKSAN

fmc Subsidiary of FOOD MACHINERY AND CHEMICAL CORPORATION

CHIKSAN COMPANY—BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries: Chiksan Export Company • Chiksan of Canada Ltd.

For more data on advertised products, use Readers' Service Cards, last page.

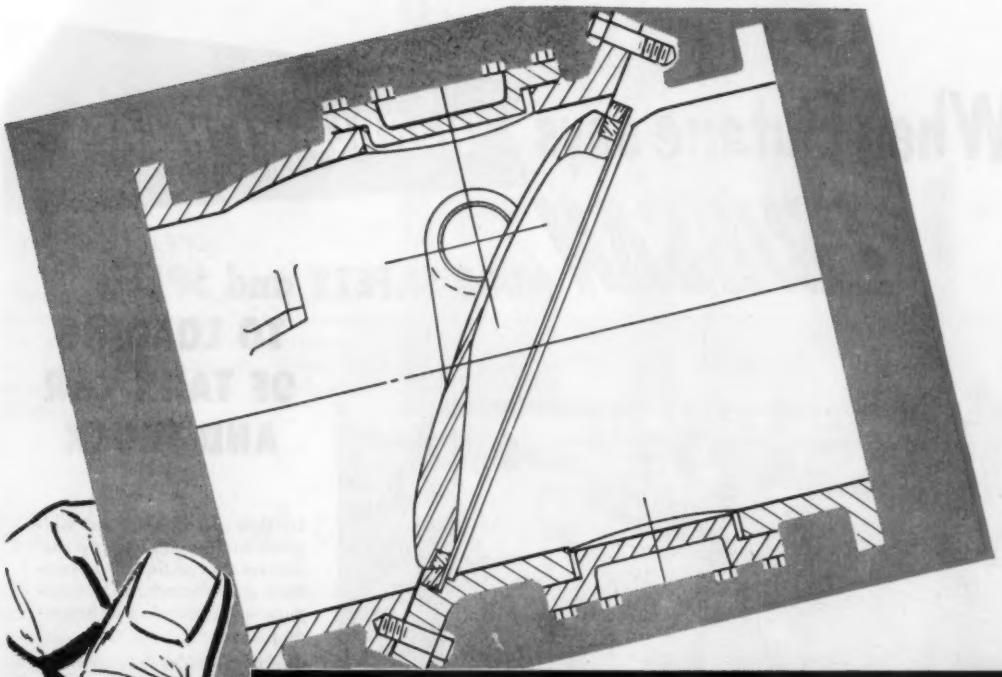


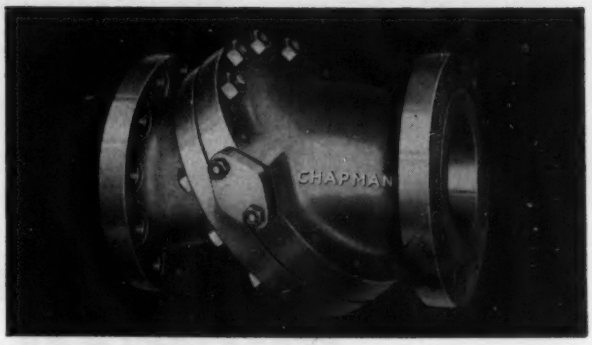
Diagram for quick, quiet, low-cost valve operation

Here's the picture . . . a cross section showing the working principles of the Chapman Tilting Disc Check Valve. It makes sense. It's a clear-cut diagram of a way to save dollars.

Notice the body design — plenty of room allowed to eliminate flow resistance, and the balanced "Airfoil" disc supported on a pivot. When the flow is on, disc opens wide enough to meet the demands of the flow. When the flow is off, disc drops quickly to a firm, tight seat. This is not only quick operation . . . it's quiet operation. There's no flutter. No banging. No slamming. No scraping of disc and seat. All this, of course, means low-cost operation. There's nothing to cause wear and tear or damage to valve or system. Your maintenance costs are low even under severe conditions.

CHAPMAN
Tilting Disc Check Valve

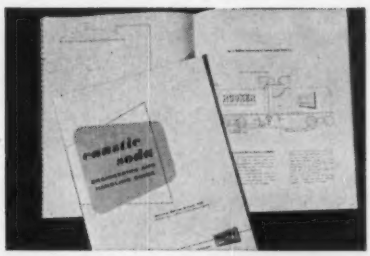
For best results in handling fluids or gases at the lowest cost, specify Chapman Tilting Disc Check Valves. They cover a wide range of pressures and are available in iron or steel. You'll find them all with complete data in our Catalog 30-A. Write for your copy, now.



The CHAPMAN
Valve Manufacturing Co.
INDIAN ORCHARD, MASSACHUSETTS

BRIEFS for buyers of

Caustic Soda
Caustic Potash
Other Chemicals



Here's newest data on caustic soda handling

This new bulletin can help you handle and store liquid caustic soda safely, efficiently, and with minimum risk of iron contamination.

Its 40 pages include large, detailed diagrams of equipment; a section on materials of construction; recommendations for unloading, dilution, piping, and storage; and a section on safety precautions and first aid.

For a copy, check the coupon for Hooker Bulletin 102, *Caustic Soda Engineering and Handling Guide.*

Helpful hints for buyers

In case you haven't received a copy, here's another bulletin packed with useful information on caustic soda.

This one is edited especially for buyers. It's pocket size for ready reference. Besides data on forms and grades of Hooker caustic soda, it includes facts on the economics of 50% vs. 73% liquid solutions; capacities of tank cars and other containers; and useful shipping information.

For a copy, just check the coupon for the *Caustic Soda Buyer's Guide.*

Caustic potash:
can you consolidate and save?

If you use caustic potash as well as caustic soda, it may pay you to look into the possible savings of a consolidated source of supply.

You can get NIALK® caustic potash from us in 45% to 52% liquid solutions, and in the following solid forms as 90% material: *solid, flake, granular, walnut, broken, powder, crushed.* We also supply 85% caustic potash in flake or solid form.

Liquid forms are shipped in tank cars of 4,000- to 10,000-gallon capacity and in 55-gallon steel drums; solid forms, in steel drums.

For descriptive bulletin and data sheet, check the coupon.

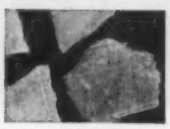
You can empty this caustic soda faster

Whether your operators scoop, pour, or shovel flake caustic soda, they'll find this new Hooker drum easier, faster, and safer to work with.

The opening on this new drum is a full 18 inches in diameter—an increase of 65% in opening area. When the drum is inverted, caustic can't pile up around the inside as it does with other standard drums.

You pay no more for this extra convenience. To get it, just specify Hooker caustic soda in the 18-inch-opening drum.

What's in the drum is your choice of any of these four sizes of uniform, nondusting flake caustic soda (shown actual size). For technical data on solid and flake forms, check the coupon.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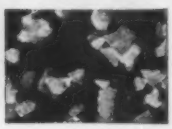
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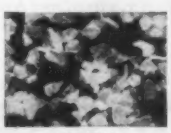
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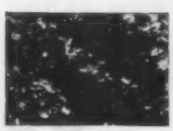

GRANULAR

For more information on chemicals discussed above, check here:

- ☐ Caustic Soda, liquid
- ☐ Caustic Soda, flake and solid
- ☐ Caustic Potash (data sheet)
- ☐ Caustic Potash (descriptive bulletin)
- ☐ Bulletin 102, *Caustic Soda Engineering and Handling Guide*
- ☐ Bulletin 101, *Caustic Soda Buyer's Guide*

Keep your file up to date with technical data on these other Hooker chemicals used in the petroleum industry:

- ☐ Antimony Trichloride
- ☐ Muriatic Acid
- ☐ Phosphorus Oxychloride
- ☐ Phosphorus Pentasulfide
- ☐ Sulfur Dichloride
- ☐ Sulfur Monochloride

Clip and mail to us with your name, title, and company address. When requesting samples, please use business letterhead to speed delivery.

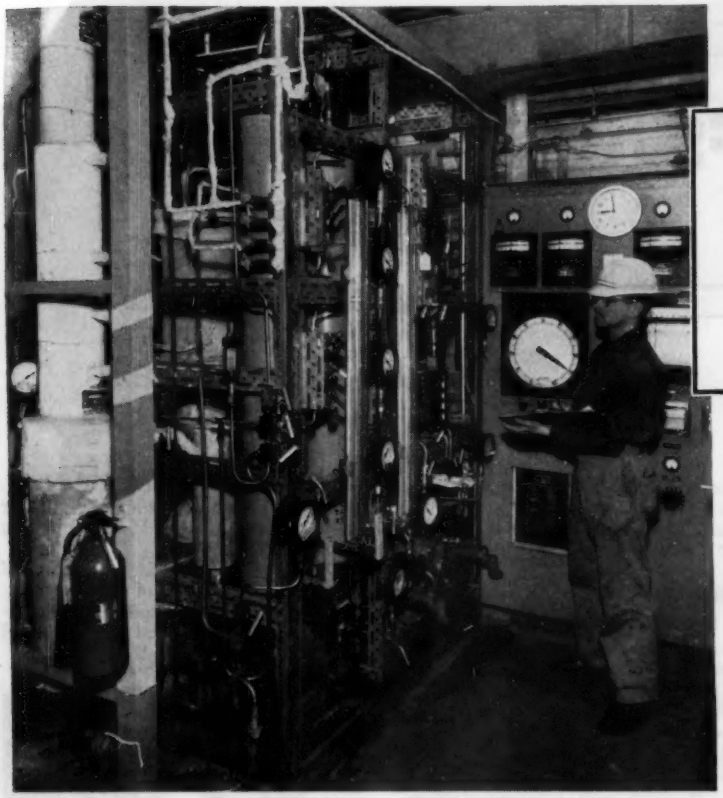
HOOKER CHEMICALS PLASTICS

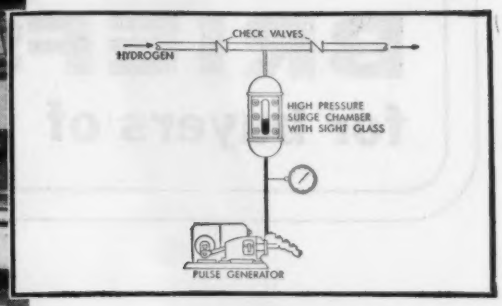
HOOKER ELECTROCHEMICAL COMPANY

1609 FORTY-SEVENTH STREET, NIAGARA FALLS, N. Y.

Niagara Falls • Tacoma • Montague, Mich. • New York • Chicago • Los Angeles

For more data on advertised products, use Readers' Service Cards, last page.





Piping system for hydrogen gas, where a Milton Roy pulse generator strokes a liquid piston which, in turn, circulates hydrogen through the check valves.

In a typical multi-purpose pilot plant, a Milton Roy duplex type pulse generator, acting on a liquid column, circulates hydrogen gas at pressures to 750 psi.

Controlled Volume Pumps assure accurate gas metering in reforming and hydrogenation pilot plants

Development engineers with multi-purpose pilot plants for reforming and hydrogenation are using Milton Roy Controlled Volume Pumps—pulse generators—to assure accurate metering of material flows. These generators stroke liquid pistons which pump and meter the gas . . . at the same time, act as seals and prevent costly leakage.

Available in simplex or duplex designs, Milton Roy pulse generators will operate liquid pistons at pressures up to 50,000 psi. The largest model—with a 3½" diameter plunger—displaces a maximum of 57.5 cubic inches per stroke.

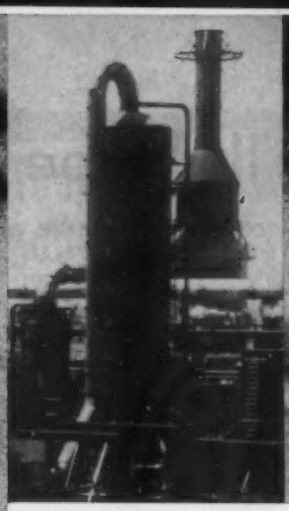
It will pay you to investigate this approach. Wherever you use Milton Roy Controlled Volume Pumps, you'll find reduced chemical costs . . . upgraded product quality . . . savings in operating and maintenance expense. Milton Roy Company, *Manufacturing Engineers*, 1300 East Mermaid Lane, Philadelphia 18, Pa.

Write for application data on Controlled Volume Pumps as used in Pilot Plant Gas Recycling Systems (Data Sheet E-57-2).

milton Roy
CHEMICAL FEED SYSTEMS

Engineering representatives in the United States, Canada, Mexico, Europe, Asia, South America, Africa and Australia

For more data on advertised products, use Readers' Service Cards, last page.



WHEN you consider expansion...

...the most important

investment you can make is in

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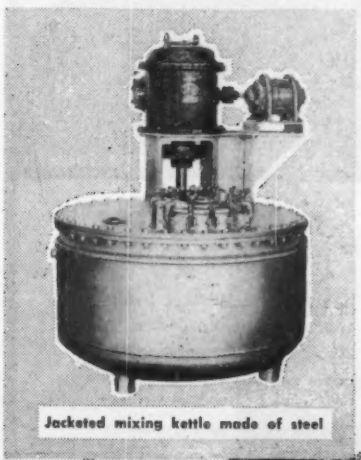

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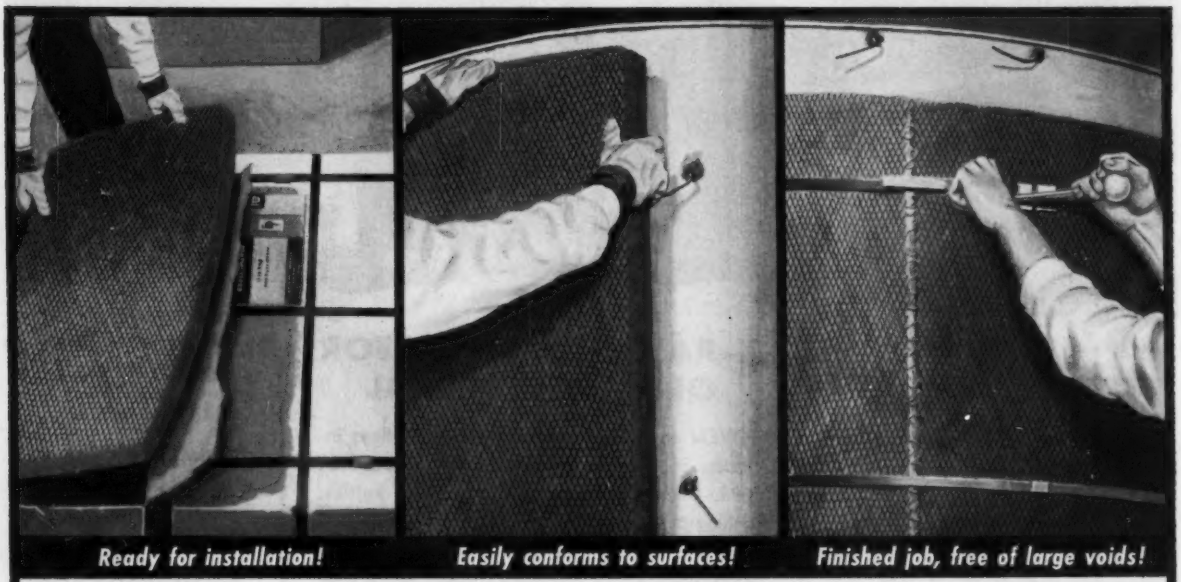

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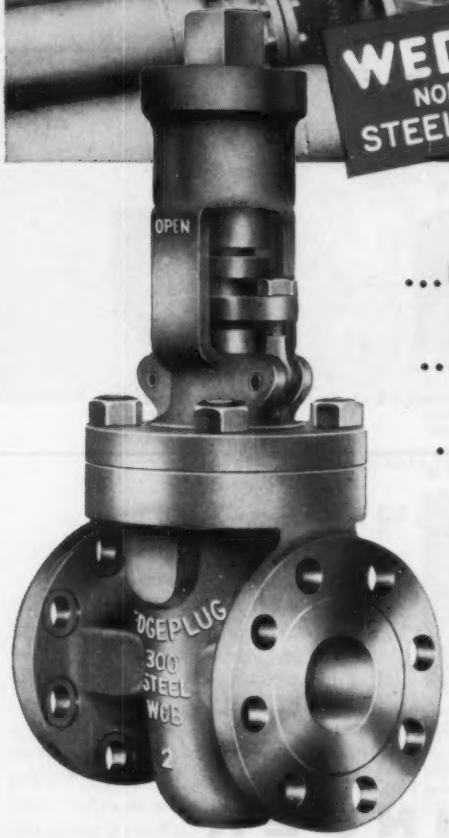

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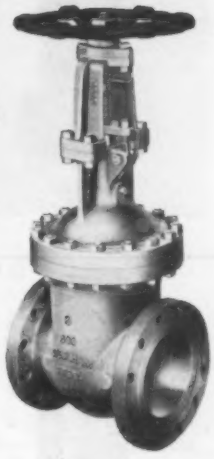

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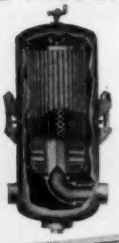

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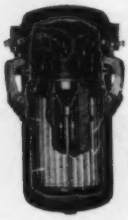

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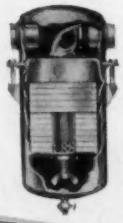

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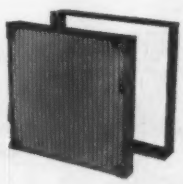

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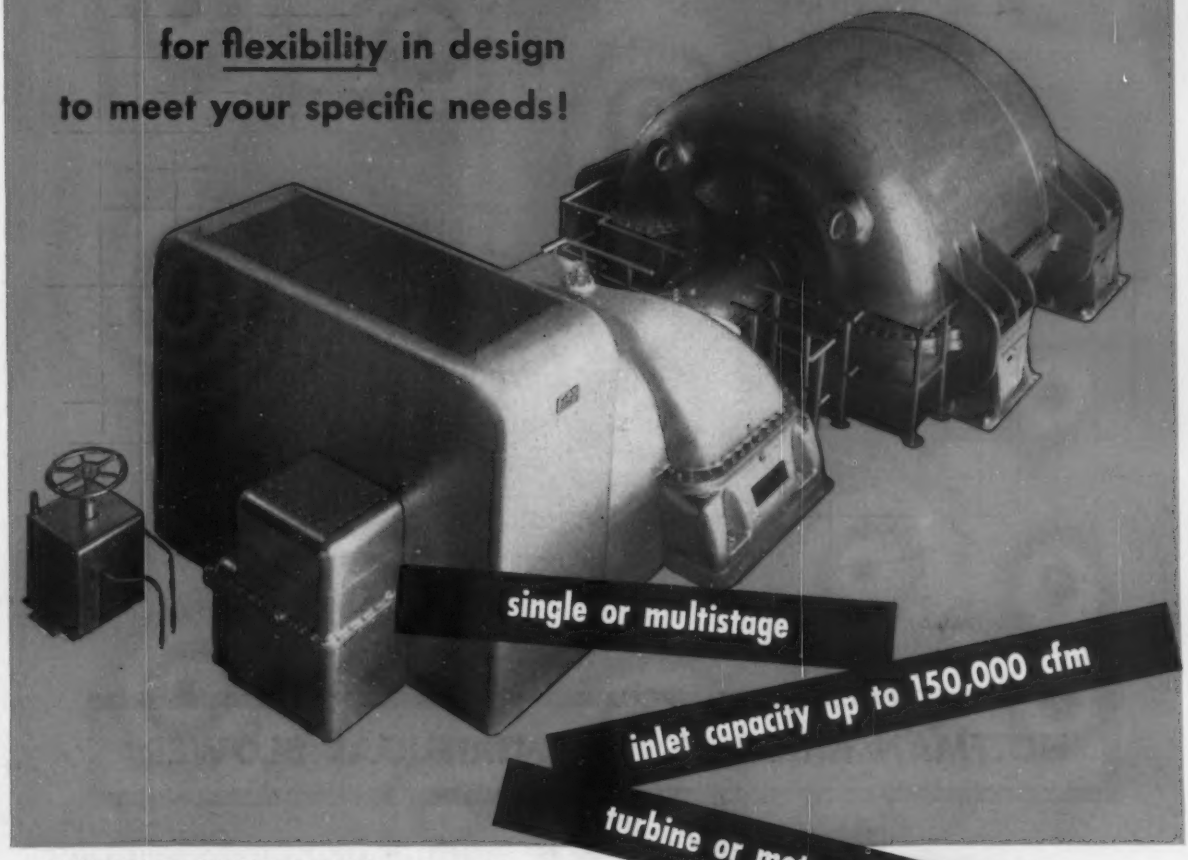

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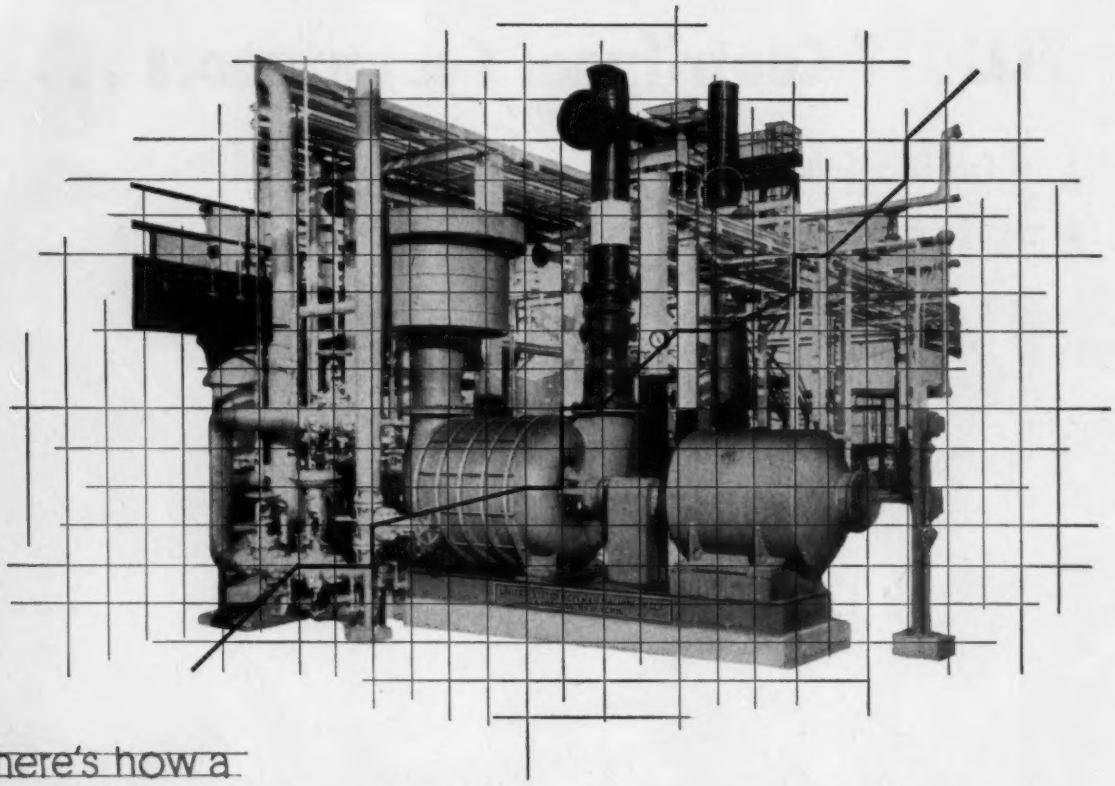

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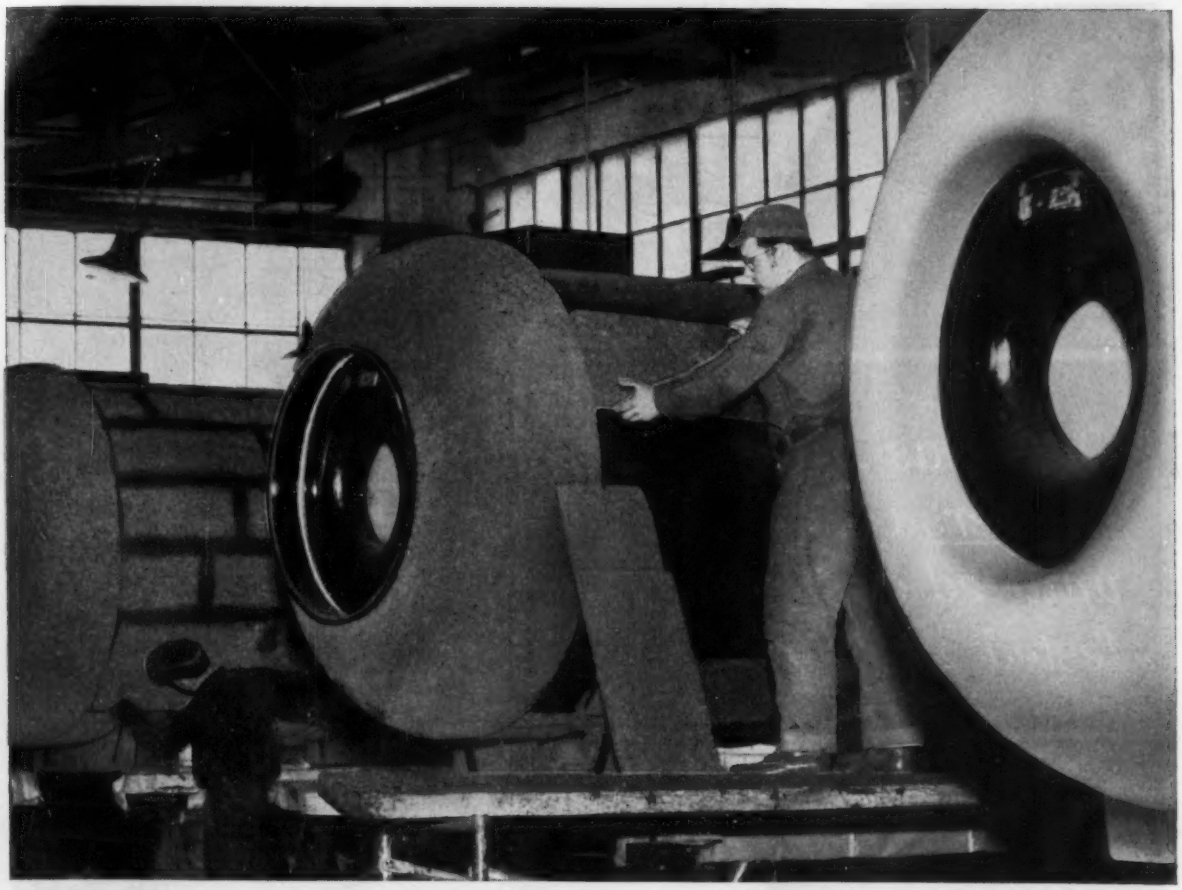

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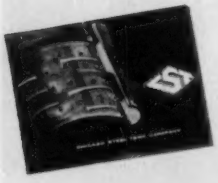

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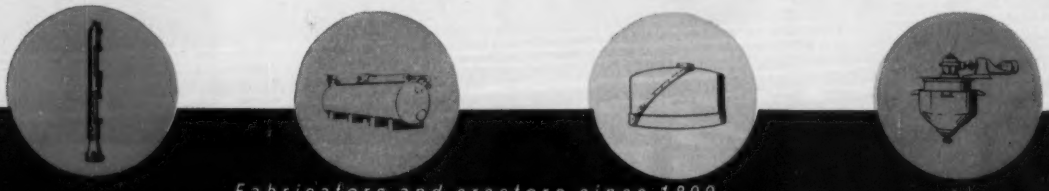

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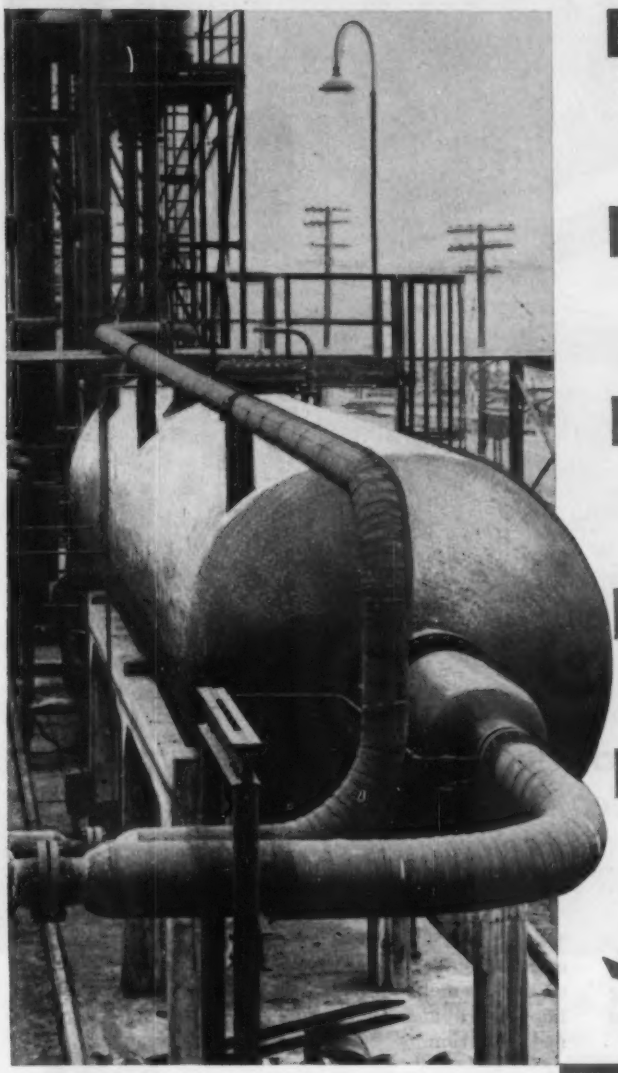

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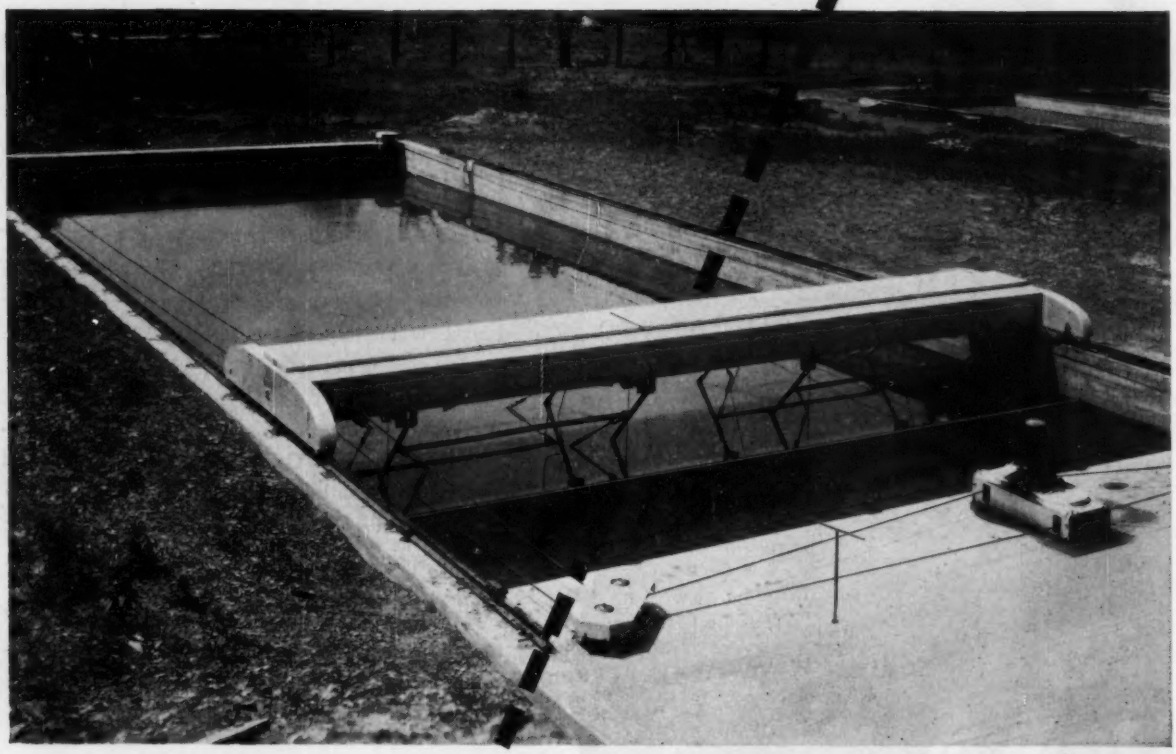

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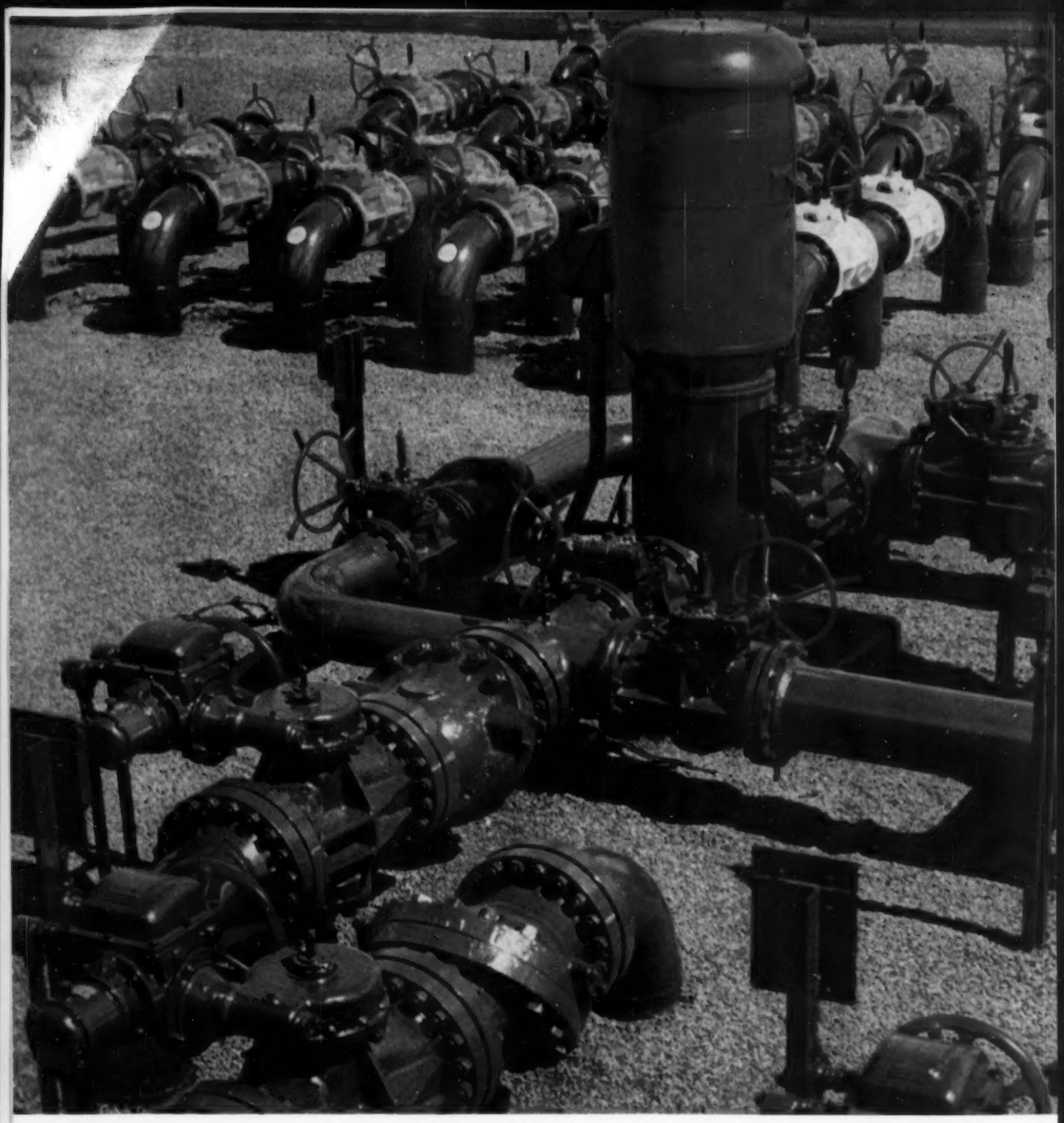
Lubricant Sealed For Positive Shut-Off



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Manufacturers of Loading Arm Assemblies, Swing Joints, Loading Valves, Tank Fittings and Truck Tank Equipment

Foreign Manufacturers

Emco Limited, London, Ontario, Canada • Emco Brass Mfg. Co. Limited, Margate, Kent, England
Worthington Corporation, Rio De Janeiro, Brazil, S. A. • Societe Luceat, Paris, France • Ljungmans, Malmo, Sweden

United States Representatives

P. R. Girard & Son, Chicago, Ill.
Lufkin Engineering & Equipment Co., Boston, Mass.
C. H. Currier Co., Pasadena, Calif.
Erie Meter Systems, Inc., Oakland, Calif.
The Watts Co., Houston, Tex.
Connor & Harris, Kansas City, Mo.
Manning, Hone & Siekmeier Inc., Denver, Col.
A. H. Stroyd, Pittsburgh, Pa.
Phil S. Crutcher, Jr., Louisville, Ky.
J. A. Savage, Summit, N. J.
H. O. Link & Son, Baltimore, Md.
Equipment Sales Co., Inc., Atlanta, Ga.
Renick & Mahoney, Inc., New York, N.Y.
R. H. Wishman Co., Inc., Buffalo, N. Y.
H. G. Anderson Equipment Co., Albany, N. Y.
Edward F. Worden Co., Detroit, Michigan

Foreign Representatives

E. A. Tessada, Mexico City, Mexico • A. Solares Y Cia., S. En C., Havana, Cuba

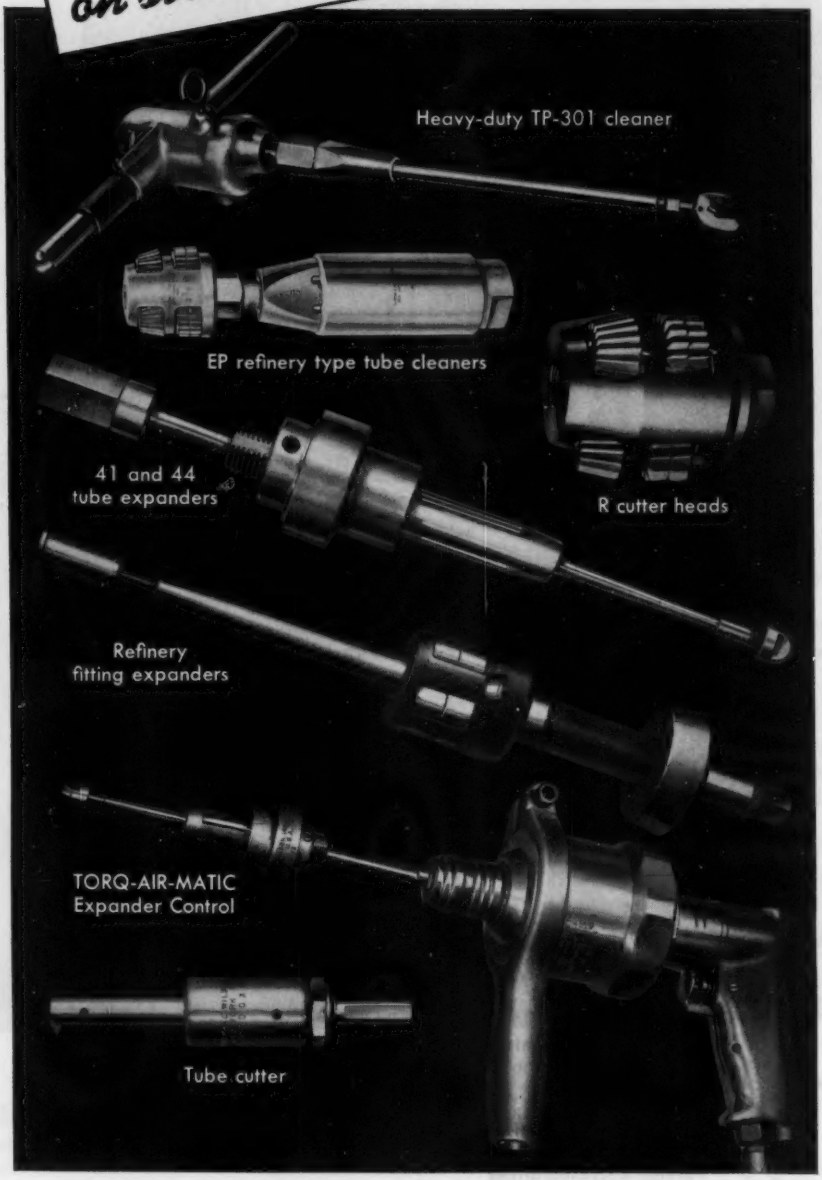
Tank Fittings by Wheaton

the best by every standard

For more data on advertised products, use Readers' Service Cards, last page.

Keep tubular equipment on stream with...

WILSON
MAINTENANCE TOOLS



Heavy-duty TP-301 cleaner
Powerful air-driven, hollow rotary shaft, drill type tool. Tube is scavenged with air or water while cleaning.

EP refinery type tube cleaners
These heavy-duty "matched sets" are designed for rugged service in removal of heavy coke or scale deposits from still tubes, transfer lines, service pipe lines, etc.

R cutter heads
The Model R is a self-feeding, double expansion head, specifically designed to endure sustained abuse with the minimum of maintenance. Excellent for refinery still tubes.

41 and 44 tube expanders
Wilson Models 41 and 44 Tube Expanders incorporate an improved, adjustable ball bearing thrust collar and are designed for efficient, easy rolling and maximum roll length adjustment for various tube sheet thicknesses.

Refinery fitting expanders
Various heavy-duty expanders are available for all types and sizes of refinery fittings and tubes. Made of the best steel available for this purpose.

TORQ-AIR-MATIC Expander Control
The Wilson Torq-Air-Matic is the first and only air-driven tube expander drive that accurately controls tube expansion by directly measuring torque output at the mandrel.

Tube cutter
Wilson tube cutter is easy to use and does a fast job. Just chuck it into existing drill. Cutter sizes available to meet all heat exchanger requirements.

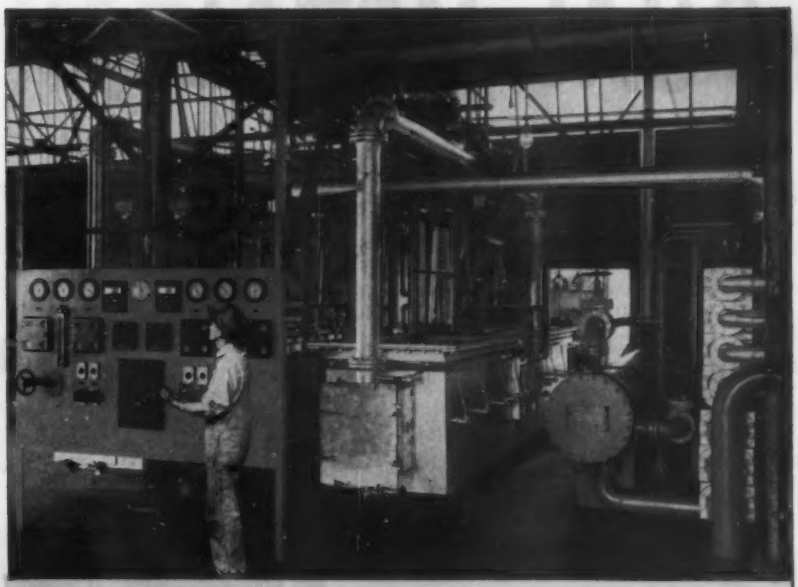
Representatives in principal cities
THOMAS C. WILSON, INC. • 21-11 44th Ave., Long Island City 1, N. Y.
Cable address: "Tubeclean", New York

TW 673

WILSON
TUBE CLEANERS • TUBE EXPANDERS

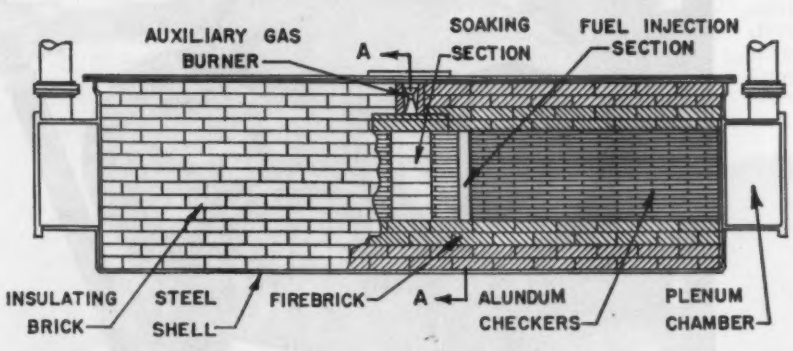
Write today for your copies of Wilson Tube Cleaner catalog No. 77 and Wilson Tube Expander Catalog No. 88.

ALUNDUM* checkers give 4 years continuous service

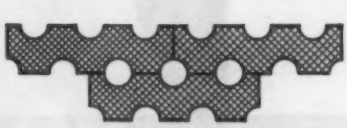


In this double regenerative furnace the Wulff Process Company of Huntington Park, Calif., produces acetylene starting with propane or other petroleum gas as the raw material. The Wulff Company reports that ALUNDUM checkers in this equipment are still going strong after continuous service, five days a week for more than four years.

Wulff Process Company says no replacement required in acetylene producing furnaces



Cross sectional diagram shows, in yellow, the location of Norton ALUNDUM checkers in the Wulff furnace. Air, preheated in the first ALUNDUM regenerator to 1800° F., is mixed with gas in the fuel injection section producing high temperatures and transferring this heat to the second regenerator. A propane-steam mixture is then passed in the opposite direction through the regenerators, heating and cracking in the second and cooling in the first. The heating and cracking cycles are both of one minute duration. ALUNDUM checkers take this extreme cyclic thermal stress and provide efficient, low cost operation.



Tubular passages for preheated flow are formed by ALUNDUM checkers. Their resistance to the erosion of hot gases is extremely important in many installations. Also, their purity is essential. Iron or other impurities could result in harmful side reactions in such gas cracking operations.

Norton refractories, engineered and prescribed for better performance in many types of equipment, provide long life, exceptional hot strength and maximum protection against the mechanical and chemical attacks of a wide variety of fuels. For further facts on these advantages write to NORTON COMPANY, Refractories Division, 468 New Bond Street, Worcester 6, Mass.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products... to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Grinding Machines • Refractories
BEHR-MANNING DIVISION PRODUCTS: Coated Abrasives • Sharpening Stones • Behr-cat Tapes

DUAL METAL··· answer to

What is it ?

To thirty-one of America's largest industries with problems of abrasion or corrosion — or both —"Dual Metal" means U. S. Pipe's Steel and Tubes Division.

Specifically, "Dual Metal" is our name for centrifugally cast cylindrical sections in which two dissimilar metals are bonded metallurgically by centrifugal force and temperature.

"Dual Metal" centrifugally cast, integrally fused combinations of two dissimilar metals are doing industry's most difficult and exacting jobs better and more economically than ever before.

Design engineers have been quick to recognize the outstanding merits of a process capable of combining the desired mechanical and chemical properties no single metal possesses.

"Dual Metal" means versatility, efficiency and economy.

Research and development play a vital and important role in the centrifugal casting of "Dual Metal" combinations. Our Pilot Foundry is devoted entirely to process and product improvement.

UNITED STATES PIPE & FOUNDRY CO.

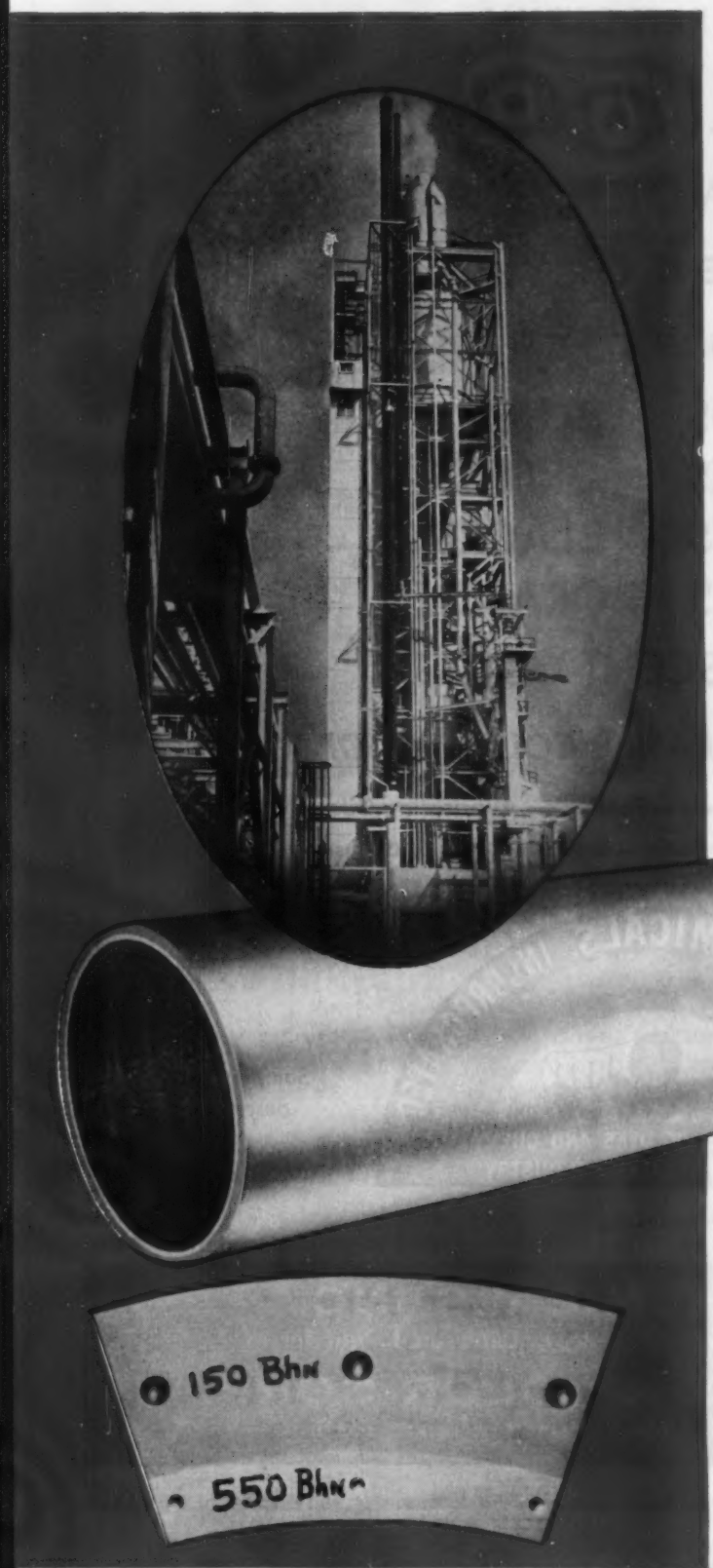
Steel and Tubes Division

STEEL & TUBES U.S. PIPE DIVISION

BURLINGTON, NEW JERSEY

SALES OFFICES: LOS ANGELES, SAN FRANCISCO, CHICAGO, ST. LOUIS, COLUMBUS, DETROIT, PITTSBURGH, HARTFORD, BURLINGTON

your TURNAROUND problems



"Dual Metal" solves one of the petroleum industry's most severe and costly problems — catalyst erosion of lift pipe and catalyst handling lines.

In making a "Dual Metal" lift pipe the outer shell of weldable alloy steel is poured into a rapidly rotating mold. The abrasion-resistant alloy iron core is introduced at the proper time and temperature. Result? A metallurgically bonded two-metal structure that combines the strength and weldability of low alloy steel and the superior abrasion resistance of alloy iron.

"Dual Metal" lift pipes are now in use in over 80 of the nation's leading refineries. In one typical refinery periodic examinations of high temperature catalyst pipes have indicated abrasion resistance of better than 16 to 1 over conventional steel piping. A once-troublesome bottleneck in processing has been eliminated and turnaround operations made shorter — a major saving of both time and money.

Perhaps this versatile process is the answer to your particular problem. Write today for specific literature and information on "Dual Metal's" applications for the refining industry.

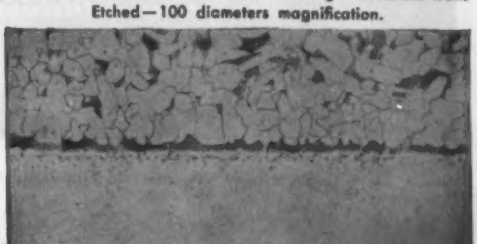
"DUAL METAL" CENTRIFUGAL CASTINGS: SIZE RANGES

OUTSIDE DIAMETER: 6" to 50" WALL THICKNESS: ½" and up
LENGTH: Up to 16 ft.
TYPICAL OIL INDUSTRY APPLICATIONS: Catalyst Lift Pipe, Depressurizing Pipe, Catalyst Transfer Lines, Slush Pump Liners, Valve Nozzles, Extrusion Liners, etc.

Left. Cross-section view of dual metal piping consisting of a weldable SAE 4120 steel outer shell and a metallurgically bonded inner layer of high carbon-high chromium abrasion resisting iron. Photograph actual size. Composition of the hard inner layer:

C	Mn	P	S	Si	Cr
2.85	1.10	.009	.023	.85	29.36

Below. Photomicrograph showing the bond or fusion zone between the outer and inner metals. The mild etch required for the 4120 steel did not attack the high chromium iron. Etched — 100 diameters magnification.



COLORS

FOR PETROLEUM

IN FLUID FORM

DYE CONCENTRATES*

by **PATENT CHEMICALS**

the Pioneers in Petroleum Dyes

REDS **BLUES**
PURPLES **GREENS**
YELLOWS **BLACKS**
BROWNS **ORANGES**
FLUORESCENT COLORS

FOR CLEANER EASIER COLORING OF

Gasolines — Diesel Fuels — Fuel Oils — Lubricating Oils
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Dye concentrates can be prepared to customer specifications.

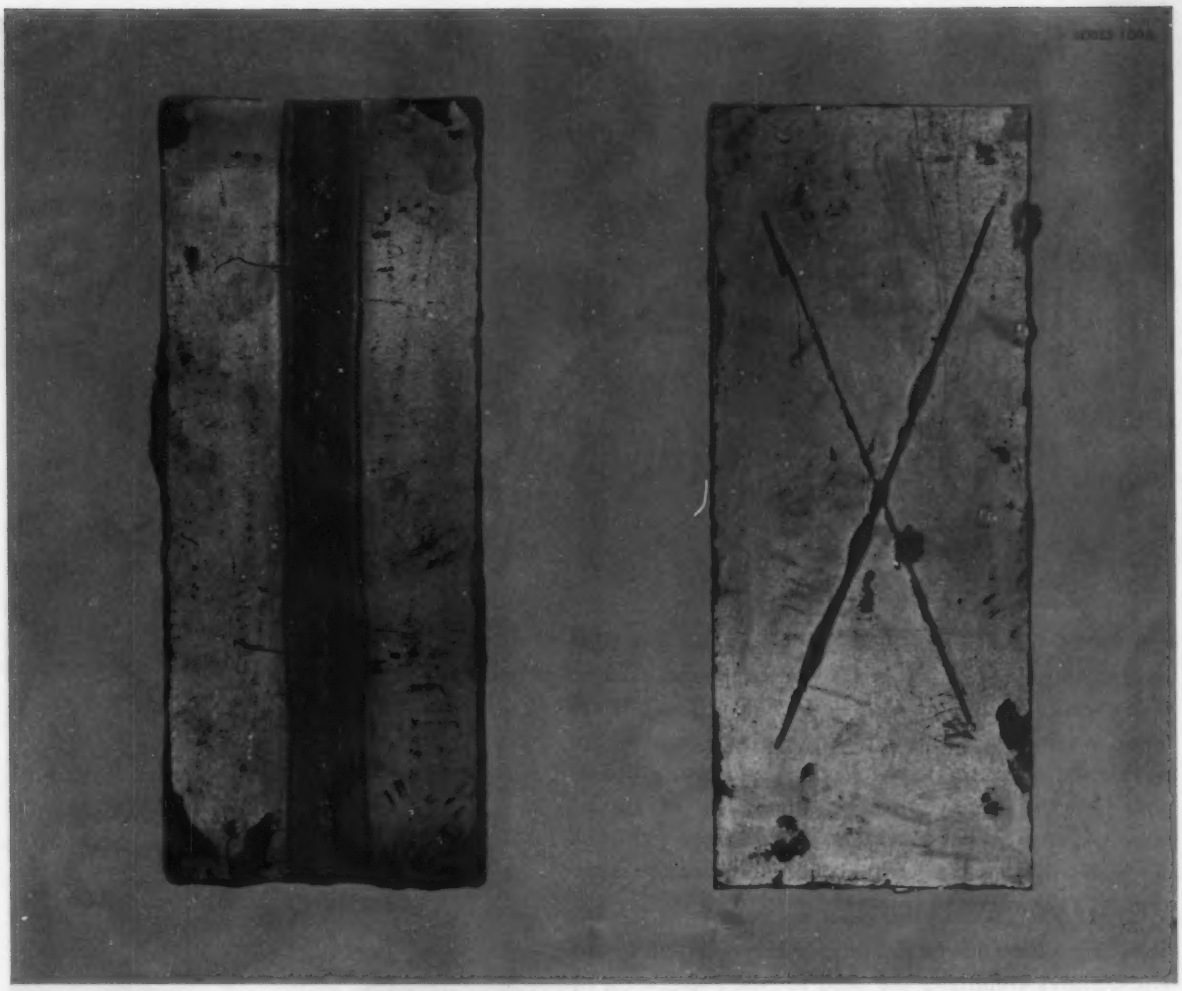
PATENT CHEMICALS, INCORPORATED
MANUFACTURERS OF DYES AND CHEMICALS FOR THE PETROLEUM INDUSTRY

Samples and description upon request.

*Patent Pending

PATENT CHEMICALS INC.
Manufacturing Division: 335 McLean Blvd., Paterson 4, New Jersey

PATENT FUELS & COLOR CORP.
Marketing Division: 2410 Carew Tower, Cincinnati 2, Ohio



CORROSION'S FOCAL POINTS are easy to detect with a new Amercoat testing method using iron and caustic indicators in a saline gelatin bath. On the welded and scored steel panels shown above after test, unworked surface areas turned red to indicate cathodic properties; but the weld, scores and edges turned blue (here shown blackened) to reveal themselves as anodic corrosion breeders. Rivets, threads, crevices and abrasions also show anodic under test. Unless such areas are effectively sealed from moisture, oxygen and ions they will erupt as focal points of corrosion cells.

How to protect "trouble spots" against corrosion

Ask a corrosion engineer where metal corrosion is likely to attack first. Chances are that he will name rivets, threads, sharp edges, angles, crevices and welds. These are the areas of stress concentration, work hardness, fissures and abrasions. They tend to be anodic and actually breed corrosion. And although they warrant increased protection, conventional coatings pull away from their sharp profiles and leave them inadequately covered.

Amercoat No. 87, a true vinyl mastic, protects these spots in a single coat 10 mils thick, whereas other coatings fail to build 5 mils in three coats. It cuts maintenance painting costs up to 50% because you don't have to re-erect staging and scaffolds for additional coats, and you get results that last.

No. 87 combines the time-tested chemical and weather resistance of vinyl coatings with the thickness of mastic, yet it is easily sprayed with standard equipment over a suitable primer. Available in white, gray, black and aluminum. Use it for enduring protection at lower cost per square foot per year. Complete details mailed on request.—Amercoat Corp., South Gate, Calif.

AMERCOAT Corporation, Dept. VI
4809 Firestone Blvd., South Gate, Calif.

Please send me your latest information on Amercoat No. 87.

Name_____

Position_____

Company_____

Address_____

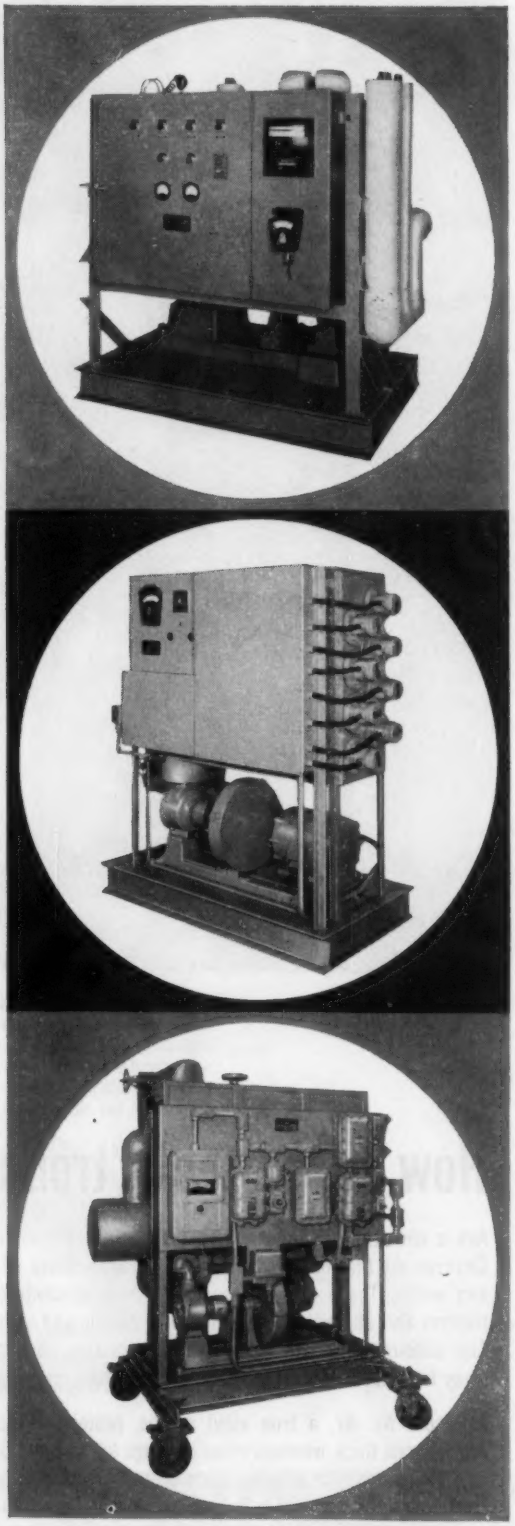
City_____ Zone____ State_____

Amercoat® CORPORATION

EVANSTON, ILLINOIS • KENILWORTH, NEW JERSEY
JACKSONVILLE, FLORIDA • HOUSTON, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

Complete transfer oil heating systems in compact "packages"



WHITLOCK offers these standard "packages" including heating unit operating controls and expansion tank to heat chemically stable transfer oils. Since these oils are liquid over considerable temperature ranges, they are being used increasingly in chemical processing operations. The heating equipment, previously of special design, is now available as complete, standardized units to which only oil and electrical connections need be made to permit immediate operation.

The combination of low liquid pressures and high liquid temperatures eliminates the need for the application of high pressure design techniques to many current processes. In more and more installations these new "packages" are effectively serving to reduce overall equipment costs and simplify process design. The units are available in Standard, or Group 1 Class D Explosion-proof Constructions. Temperature controls are carefully selected to maintain the oil supply temperature within ±2° F and the design precludes oil deterioration. Signal lights confirm satisfactory operation.

For additional information and prices write . . .

THE WHITLOCK MANUFACTURING COMPANY
75 South Street • West Hartford 10, Conn.

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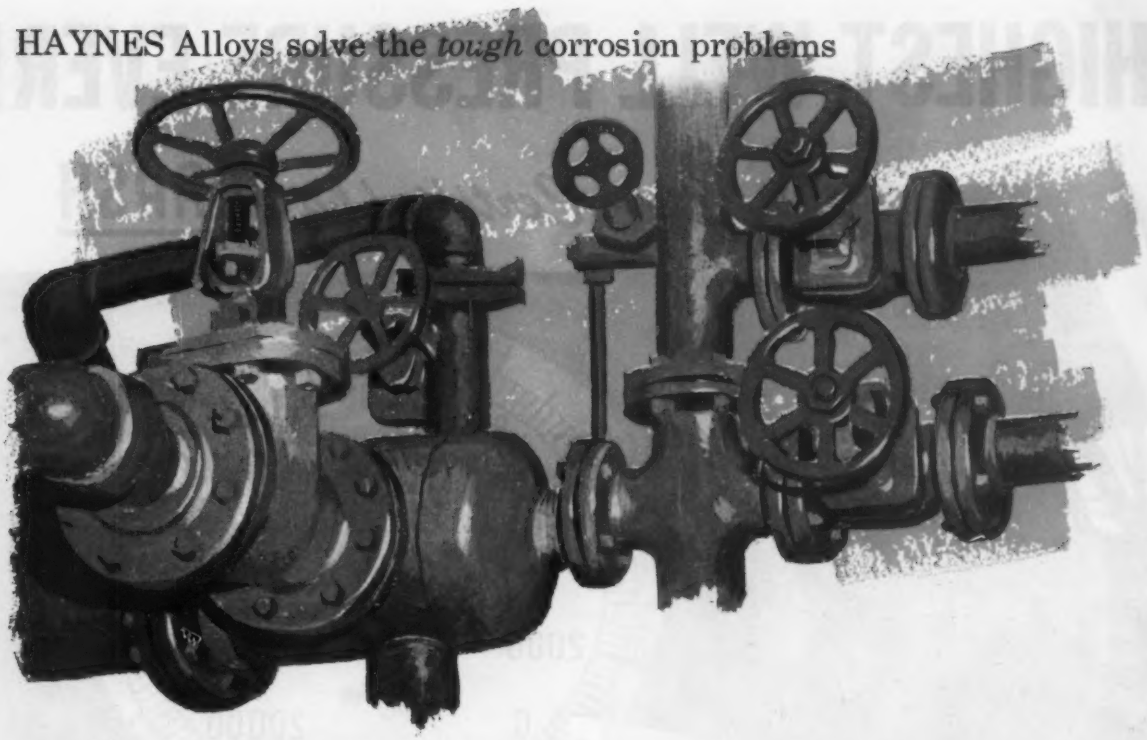
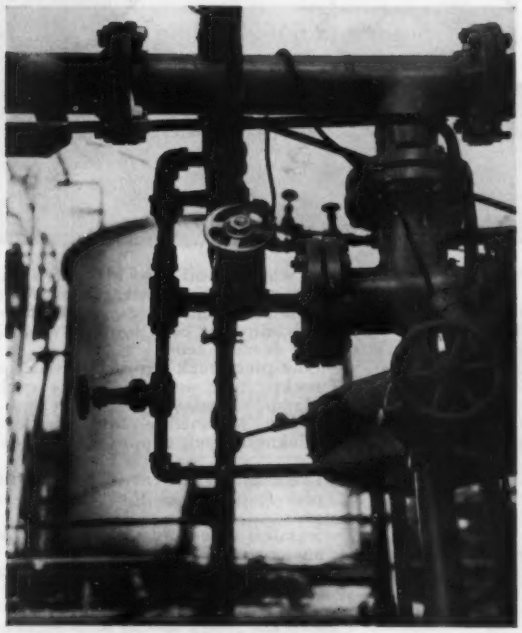
Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

For more data on advertised products, use Readers' Service Cards, last page.

HAYNES Alloys solve the *tough* corrosion problems





Valves previously used lasted only a day . . . but alloy B valves exposed to sulphuric acid and live steam while regulating flow from a neutralizer unit are expected to last indefinitely.

Refinery Corrosives Economically Controlled

Aluminum chloride, hydrogen sulphide, sulphuric acid, and other strongly corrosive media usually associated with refinery operations are handled safely and economically by equipment made of HASTELLOY alloys. Complete protection can be assured by specifying HASTELLOY alloys for use in towers, concentrator tubes, heat exchangers, tubing, pipe, pumps, and valves.

There are four HASTELLOY alloys, each specifically designed to resist certain corrosives. One or more of them can solve your corrosion problems, help to lower maintenance costs, and step up production.

For full details on physical and mechanical properties, corrosion data, and fabrication information, send for our newly published 104-page booklet. Write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation

UNION CARBIDE

"Haynes," "Hastelloy" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

HIGHEST WELL PRESSURE EVER!

—Certified by MARSH

Yes, 11,400 psi!

This was oil country drama at its best: bringing in the "2 Elue Roach" well in Union Oil & Gas Corporation's spectacular Lake Arthur Field at Jefferson Davis Parrish, Louisiana. The Marsh Gauge climbed to 11,400 psi; later reached 11,600 psi—highest shut-in tubing head pressure ever registered by an oil well, and by a good margin.

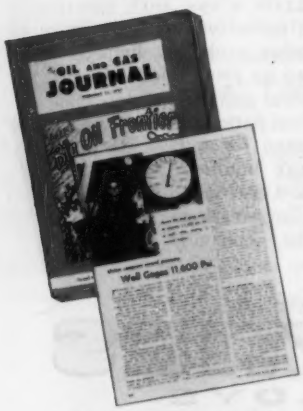
Only a few years ago oil companies were refusing to complete wells that threatened pressures of even 10,000 psi. But stronger casings, and techniques developed by Union in dealing with ever higher pressures in the Lake Arthur Field, had made "2 Elue Roach" a producing reality.

It took a lot of doing—a lot of programing and qualifying of materials—to bring in the Roach Well and the new era it foretells. So it is not surprising to see a Marsh Gauge at the top of the Christmas Tree.

Yes, wherever oil flows Marsh is at the top of the list. In the Mastergauge everything that can contribute to gauge accuracy and dependability has been brought to a higher stage of development:

- —One-piece leak-proof construction of socket, tube and tip by the exclusive Marsh "Conoweld" process.
- —Sturdy "Marshalloy" case of boiler-plate thickness steel; copper clad inside and out.
- —Precision movement with unduplicated plus features like the "coined" sector gear.
- —Stainless tubes and sockets available for any corrosive service.
- —Finally, the famous Marsh "Recalibrator" to keep the gauge always accurate.

Ask for new catalog covering Marsh instruments.



An interesting account of the method of completing the "2 Elue Roach" will be found in the February 11 issue of Oil & Gas Journal. Depth of well is 15,461 ft. Well tested 190 bbl. of condensate and 6,375,000 cu. ft. of gas daily.

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.* **Dept. R, Skokie, Ill.**
Marsh Instrument and Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas

MARSH GAUGES

"THE STANDARD OF ACCURACY"

GAUGES • WATER REGULATING VALVES • SOLENOID VALVES • HEATING SPECIALTIES

Direct... **FACTORY-TO-YOU**

COLD-DRAWN SEAMLESS

STEEL TUBING

COLD FINISHED BARS

Direct from the largest tube mill in the West means you save time and you get what you specify. Pacific can provide seamless tubes in carbon, alloy and stainless steel, and electric resistance welded tubing in sizes up to 4 inches in diameter. If you require extra-long tubing, Pacific is equipped to cold draw straight lengths up to 58 feet long. Pacific tubes are "quality controlled" at every critical stage of manufacture to insure close tolerance, workability and long service life.

COLD DRAWN BARS

Precision drawn Patco round bars are quickly available in many analyses from 3/16" through 3½". A wide range of chemistries include C-1018, C-1137, C-1117, C-1045 and MCX-1213, plus Ledloy Grades A & B.

PRECISION SHAFTING

Ground, polished and stress relieved in the Pacific mill, constant laboratory inspection during every vital step insures the highest "quality controlled" product... where precision counts. Available through 2 7/16" diameter.

Avail yourself of Pacific Tubes' Engineering Service in solving your metallurgical or application problems.

PACIFIC
TUBE COMPANY

5710 Smithway Street, Los Angeles, California

Phone RAymond 3-1331

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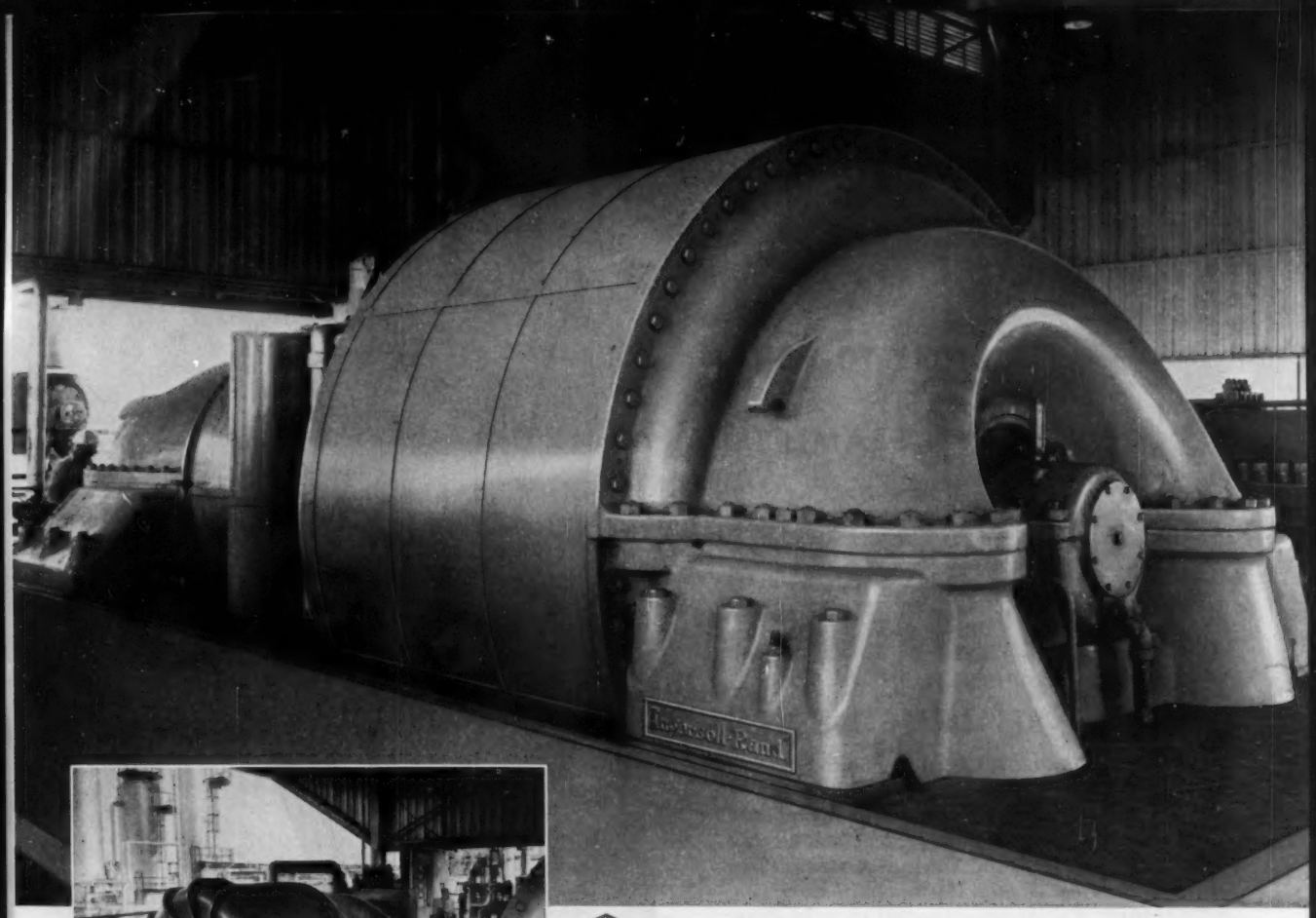
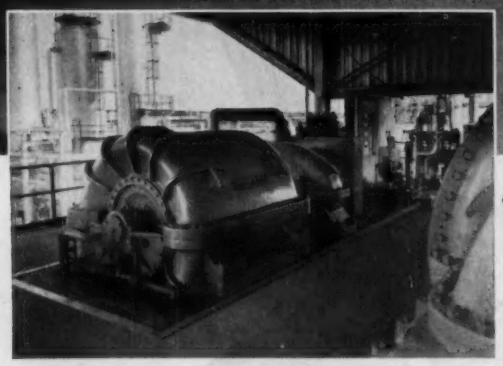
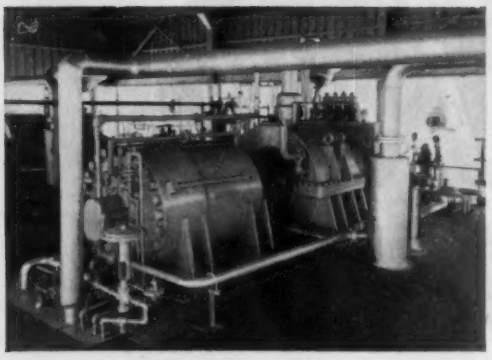


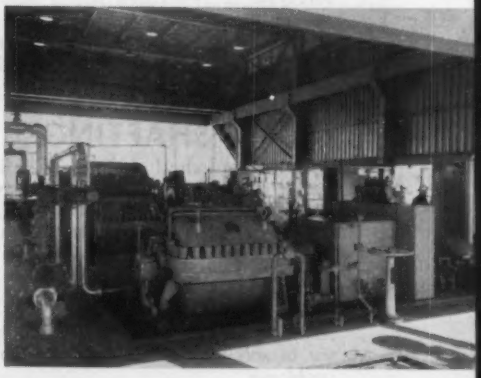


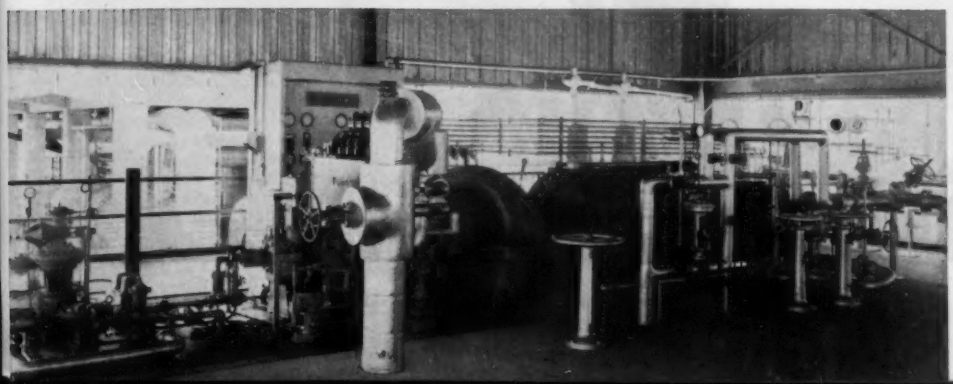
ORTHOFLOW CRACKER, the largest cat cracker ever built, is served by this huge I-R Turbo-Blower — a 161,500 cfm unit that discharges at 30 psia. It is the largest cat-cracking air blower in the world and is driven by an I-R 11,250-hp steam turbine. The 3000-hp I-R centrifugal shown at left serves as the carrier or fluidizing compressor on the cracking unit.



HOUDRIFORMER
Two I-R steam-turbine-driven barrel-type centrifugal compressors recycle hydrogen gas. Each unit is rated 5050 cfm at 675 psia discharge pressure.

GAS PLANT uses two I-R centrifugals to transfer hydrocarbon gases from the cracker. Operating in parallel, each is rated 15,500 cfm, 200 psia discharge and each is driven by an I-R steam turbine.





FLUID COKER, also the world's largest, is served by three Ingersoll-Rand Centrifugals — each driven by an I-R steam turbine. The main air blower, rated at 109,200 cfm at 29 psia is equipped with I-R adjustable inlet guide vanes to permit full-pressure operation down to approximately 30% rated capacity. At the left is one of the two tandem I-R centrifugals that serve as transfer gas compressors. Each is rated 16,100 cfm at 230 psia.

More than 65,000 hp of I-R Compressors serve

TIDEWATER
DELAWARE REFINERY

Nineteen Ingersoll-Rand compressors, representing more than 65,000 horsepower, will help the Tidewater Oil Company process 130,000 barrels of oil daily at its new Delaware Refinery south of Wilmington. The refinery is the largest ever built at one time. C. F. Braun & Co. were the engineers and constructors of the huge project which includes several processing units that are the largest of their kind.

The I-R compressors — *both centrifugal and reciprocating units* — will handle a variety of gases for the processing units. Each of the nine centrifugals is driven by an Ingersoll-Rand steam turbine. The reciprocating compressors are electric-motor-driven.

Other Ingersoll-Rand equipment used in the refinery includes ejectors and centrifugal pumps. In the general construction of the refinery, I-R tools and portable compressors were used extensively.

This outstanding installation is further evidence of Ingersoll-Rand's ability to design and build air and gas compressors that best meet the most exacting processing requirements of capacity, pressure, dependability and ease of maintenance. An I-R engineer will be glad to give you complete information on a compressor best suited to your needs.

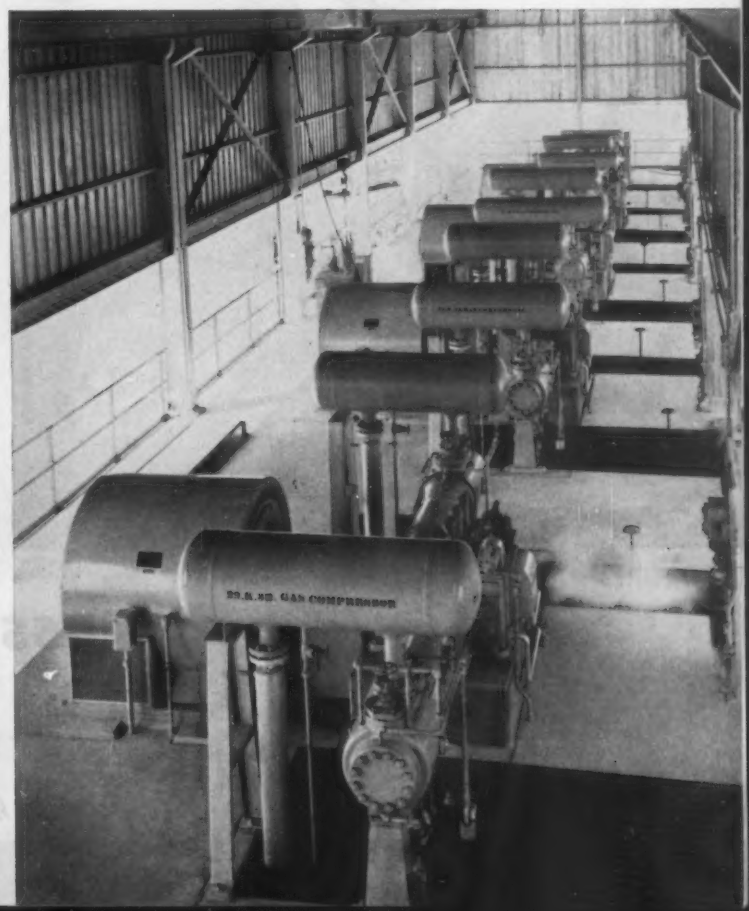
Ingersoll-Rand

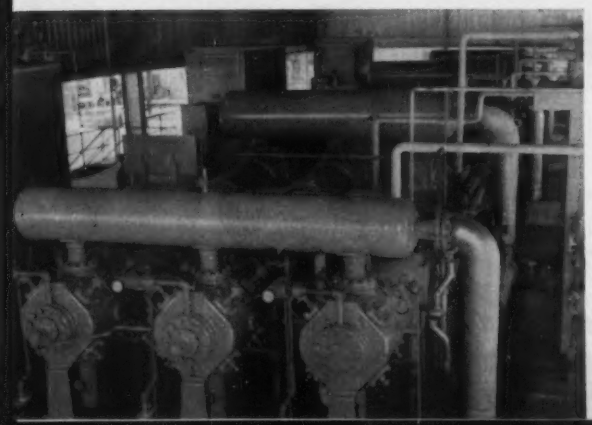
12-638 11 Broadway, New York 4, N. Y.

CENTRIFUGAL PUMPS • COMPRESSORS • TURBO-BLOWERS • VACUUM EQUIPMENT • AIR AND ELECTRIC TOOLS • DIESEL AND GAS ENGINES

DESULPHURIZATION UNIT
For circulating hydrogen gas in the desulphurization unit six Ingersoll-Rand HHE compressors are used. Two 800-hp units, not shown, have non-lubricated cylinders. An Ingersoll-Rand ES Compressor serves as a recovery compressor.

HYDROGEN PLANT—Three Ingersoll-Rand 3000-hp HHE reciprocating compressors serve the hydrogen plant which produces 30,000,000 cubic feet per day of make-up hydrogen used in the reformer and desulphurization units. Each compressor has a capacity of 2,280 cfm.





MULTIGRIP Floor Plate for safety and service in Shell refinery

Safety and durability are key factors in all refinery traffic areas. Catwalks, ladders, ramps and walkways that are in use around the clock *can* be real accident hazards as well as maintenance headaches. Avoid these problems by using USS Multigrip Steel Floor Plate.

Made from tough steel, Multigrip is built to stand up under years of punishment without chipping, cracking or splintering. Evenly spaced risers have clean edges, and flat tops that provide positive traction—from all directions. The risers' flat tops mean more comfortable footing, too. Cleaning? As the photograph illustrates, there's no problem there. A hose or broom is all it takes to keep Multigrip clean.

Installing Multigrip is never a problem. It cuts, bends, forms and welds easily. And installation waste is cut to an absolute minimum because Multigrip is available in large plates in several thicknesses. For safe footing and long service, you'll like USS Multigrip Floor Plate.

• • •

USS MULTIGRIP FLOOR PLATE installed for safety in a traffic area at Shell Oil Company's Houston Refinery.

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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USS **multigrip**
FLOOR PLATE

Sold by leading distributors from coast to coast

UNITED STATES STEEL

ACETYLENE

...bright future for an old flame!

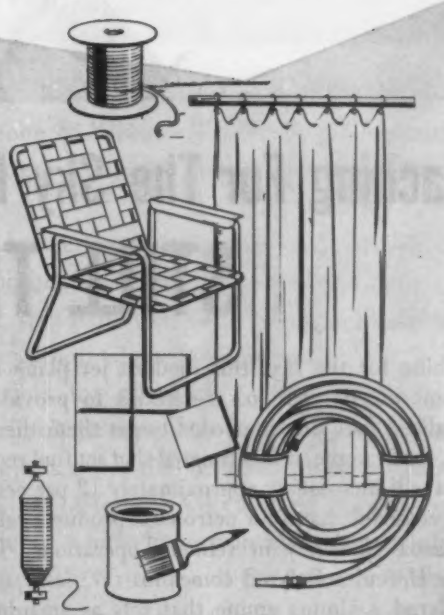
For years the use of acetylene commercially was limited primarily to the welding torch. Today, it is one of the brightest stars on the petrochemical horizon, with some 80% of total output serving as basic raw material for many of the "miracle" synthetic fibres and hundreds of other important plastic products, including *acrylic fibres, resins, solvents,* and *synthetic rubber.*

Key factor in the phenomenal growth of acetylene has been the recent development of processes for its production from natural gas. Among these new production techniques, the BASF process has had the greatest success, because of its commercially proven economy, safety and reliability.

With exclusive rights in all North American countries* for the BASF process, Chemico has designed and constructed facilities for the production of more than 150,000,000 pounds per year capacity of acetylene. This total includes the world's largest plant for producing acetylene from natural gas. This experience enables CHEMICO's highly skilled staff to handle acetylene projects with maximum efficiency and economy.

*On occasion those rights have been extended to other areas, through special arrangement with BASF.

If you are interested in the profit making opportunities offered by acetylene, we suggest you send for CHEMICO's new acetylene brochure (Bulletin No. 257), which will give you more detailed information on the BASF process and CHEMICO's experience in this field.



CHEMICAL CONSTRUCTION CORPORATION

CHEMICO

A SUBSIDIARY OF ELECTRIC BOND AND SHARE COMPANY

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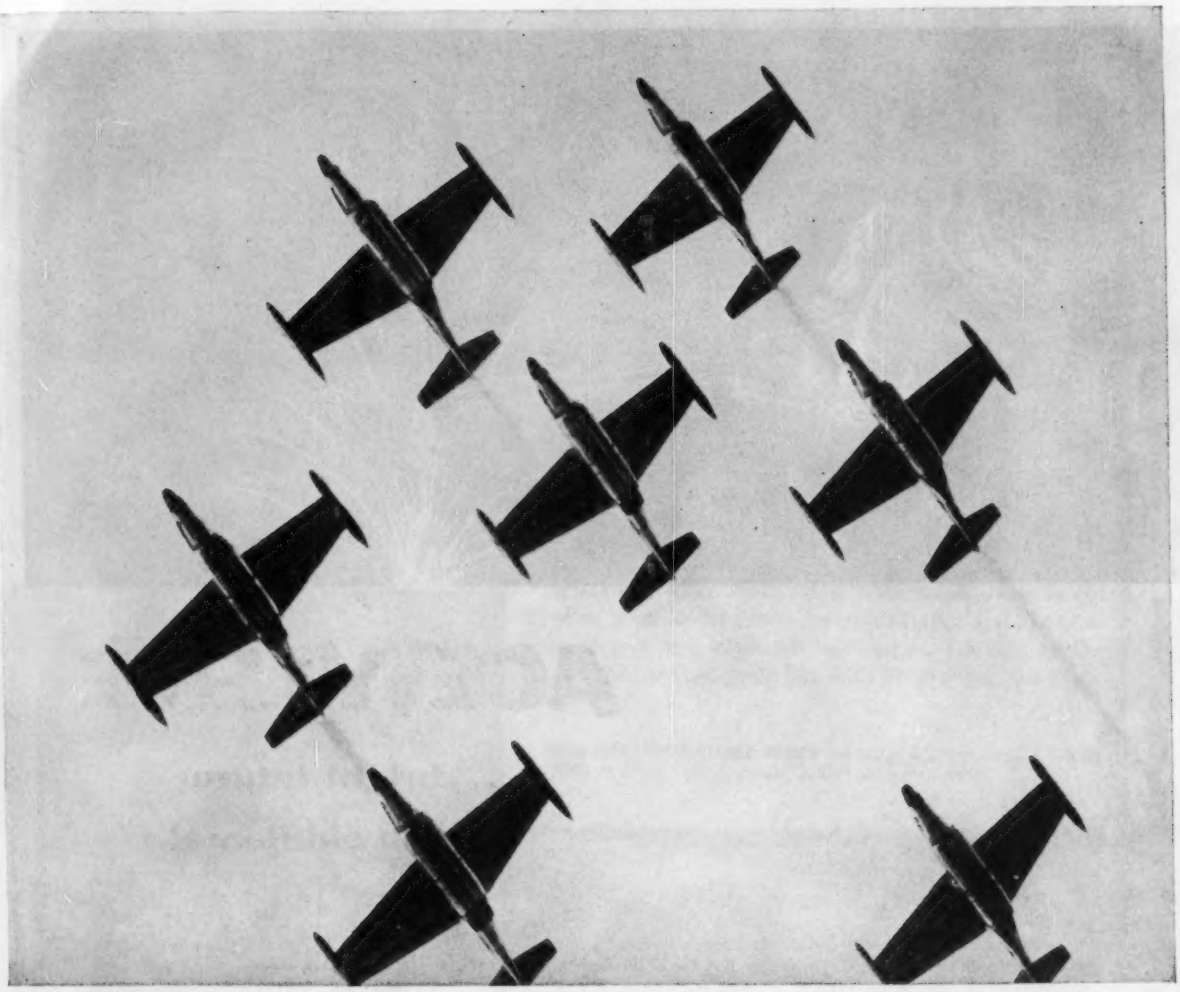

Reaching For The Sky But STILL TIED TO THE GROUND

Reaching for the sky, this modern jet plane is dependent on the nation's refineries to provide the specialized fuel that is needed to get them there. In 1957, for example, it is estimated that jet fuel requirements will increase by approximately 12 per cent.

Increased demand for petroleum products calls for increased efficiency in refinery operations. That's where Hercules Polyrad comes in.

Polyrad, a filming amine that acts as an inhibitor and detergent, helps maintain throughput, increase heat transfer, and cut down time for maintenance. At turn-around time you see the difference that Polyrad makes.

Stocks of Polyrad are maintained at conveniently located points throughout the country and overseas. We'll be glad to discuss the application of Polyrad to your specific operating conditions.

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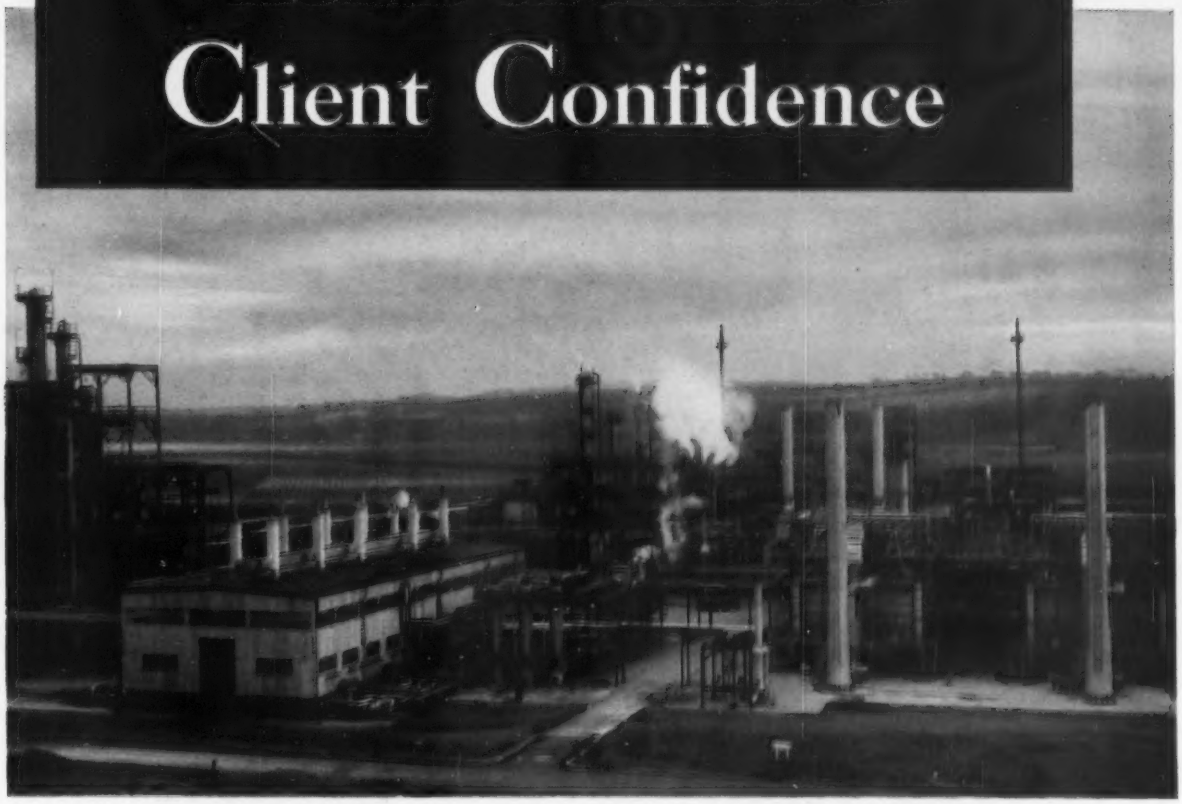
POLYRAD®
FILMING AMINE INHIBITOR

NA57-4

ANOTHER EXPRESSION OF

Client Confidence



New Ethylene and Ethanol Facilities, British Hydrocarbon Chemicals Limited.

Client confidence in Stone & Webster Engineering Corporation is expressed in these new Ethylene and Ethanol Plants at Grangemouth, Scotland.

Stone & Webster Engineering Corporation and its affiliate, E. B. Badger & Sons Limited, designed and constructed these new facilities which doubled the Ethylene and Ethanol production capacity of British Hydrocarbon Chemicals Limited.

Having been responsible for the highly satisfactory original Ethylene and Ethanol facilities, the same team has completed or is currently executing other projects at this site including plants to produce Isopropyl Alcohol, Tetramer, Detergent Alkylate and Polyethylene.

The skills and experience which have won such lasting client confidence are at your disposal. Write or call the Stone & Webster Engineering Corporation office nearest you.

STONE & WEBSTER ENGINEERING CORPORATION

AFFILIATED WITH E. B. BADGER & SONS LIMITED (LONDON)

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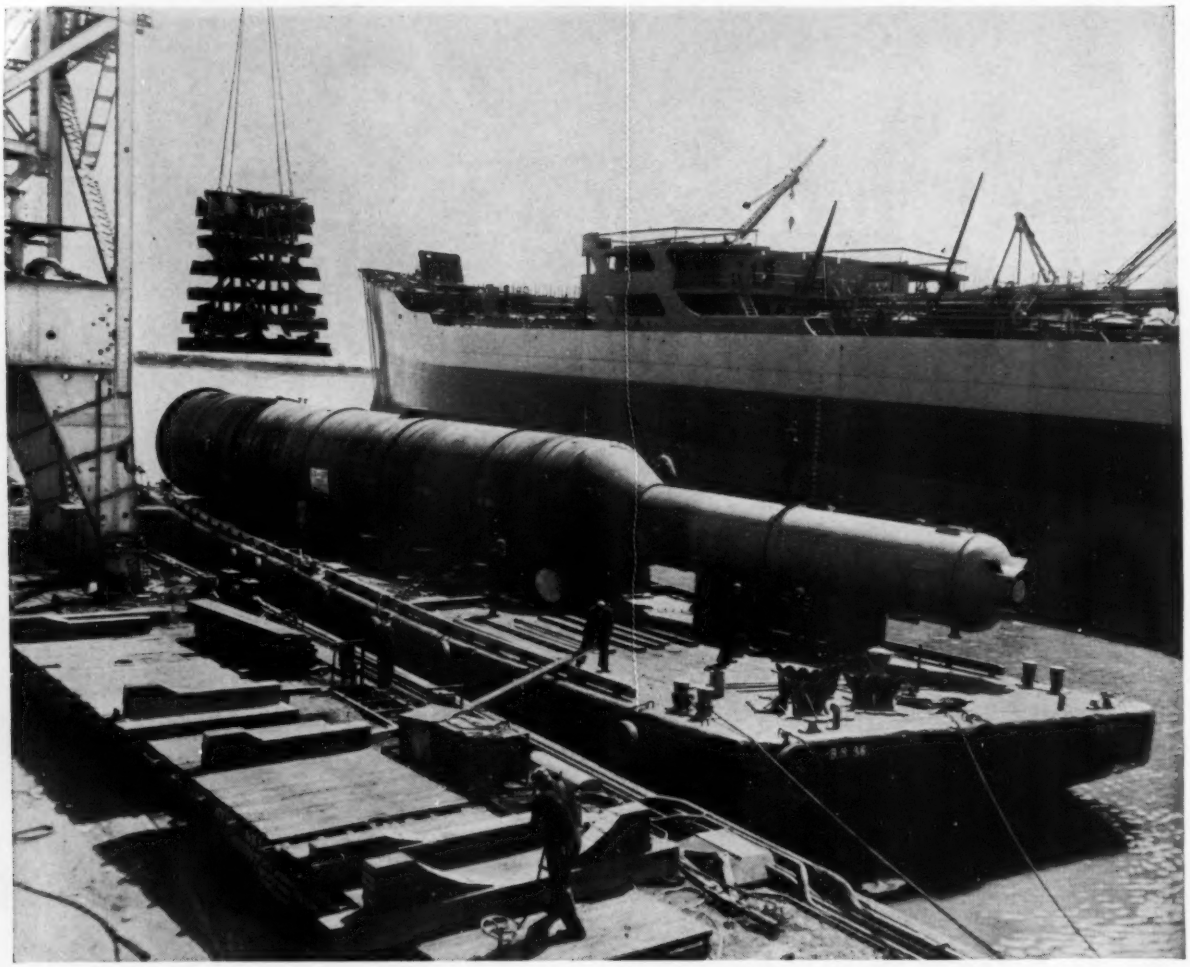

standard procedure: VERSATILITY . . .

The variety of work which Sun Ship's integrated shops produce for use by industries on land and sea brings a matching variety of shipping problems.

Our facilities for tidewater shipment are used to economical advantage on many of the massive structures that go into the making of the nation's petroleum and chemical industries. The barge shipment of tower and shed row baffles, shown above, is a good example.

And of course—when shipment by land is necessary—Sun Ship rigging and routing find the ways and means to handle such items as large-diameter columns by rail and truck.

It's all a part of the versatility which forty years' experience has made part of "standard procedure" in service of its customers.

Our Sales Engineering Department would be glad to use its experience in helping you overcome any problem of construction or shipment that faces you. Write

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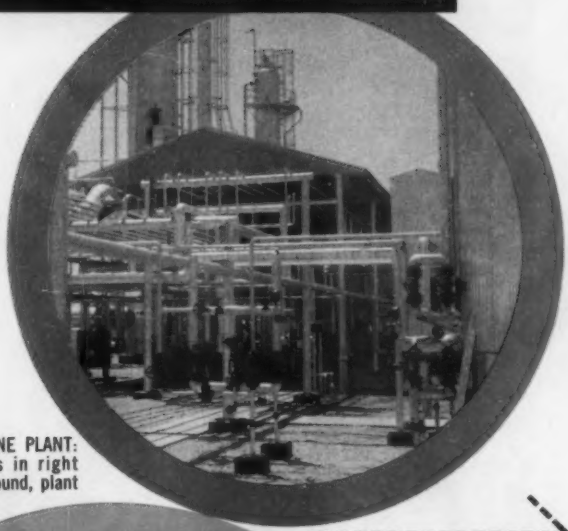
SHIPBUILDING & DRY DOCK COMPANY

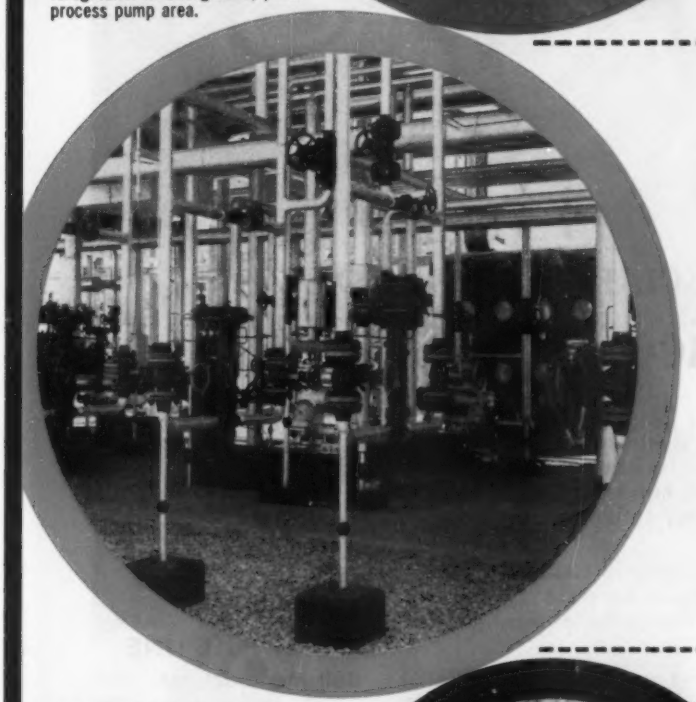
ON THE DELAWARE SINCE 1916 **CHESTER, PA.**

price is not a factor

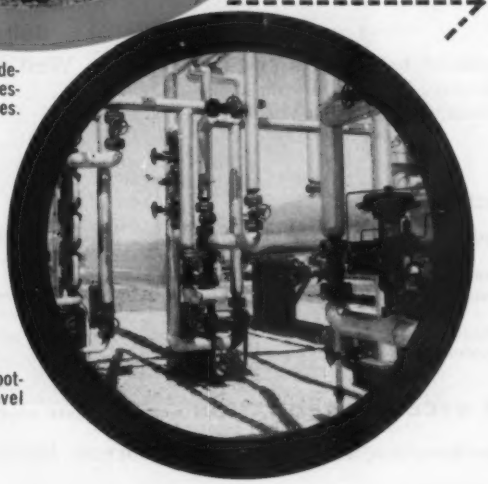
when you specify orbit forged steel asa class valves for your processing area



AT A KANSAS GASOLINE PLANT: Propane dehydrators in right foreground. In background, plant process pump area.



In foreground, depropanizer and debutanizer, reflux accumulator pressure relief and level control valves. Reflux pumps in background.



Left to right, de-ethanizer feed, bottoms exchanger, and liquid level control valve.

because:

with orbit's non-lubricated positive closure seating principle... costly maintenance is eliminated

ORBIT ASA CLASS VALVES are available in Carbon or Stainless Trim. Full Round Opening Sizes 1" thru 4". Ratings: 300 lbs. thru 2500 lbs. Flanged or Screw Ends. Venturi Opening Sizes 2" thru 6". Ratings: 150 lbs. thru 2500 lbs. Flanged End Only. Available thru your favorite oil field supply store or refinery supply house.

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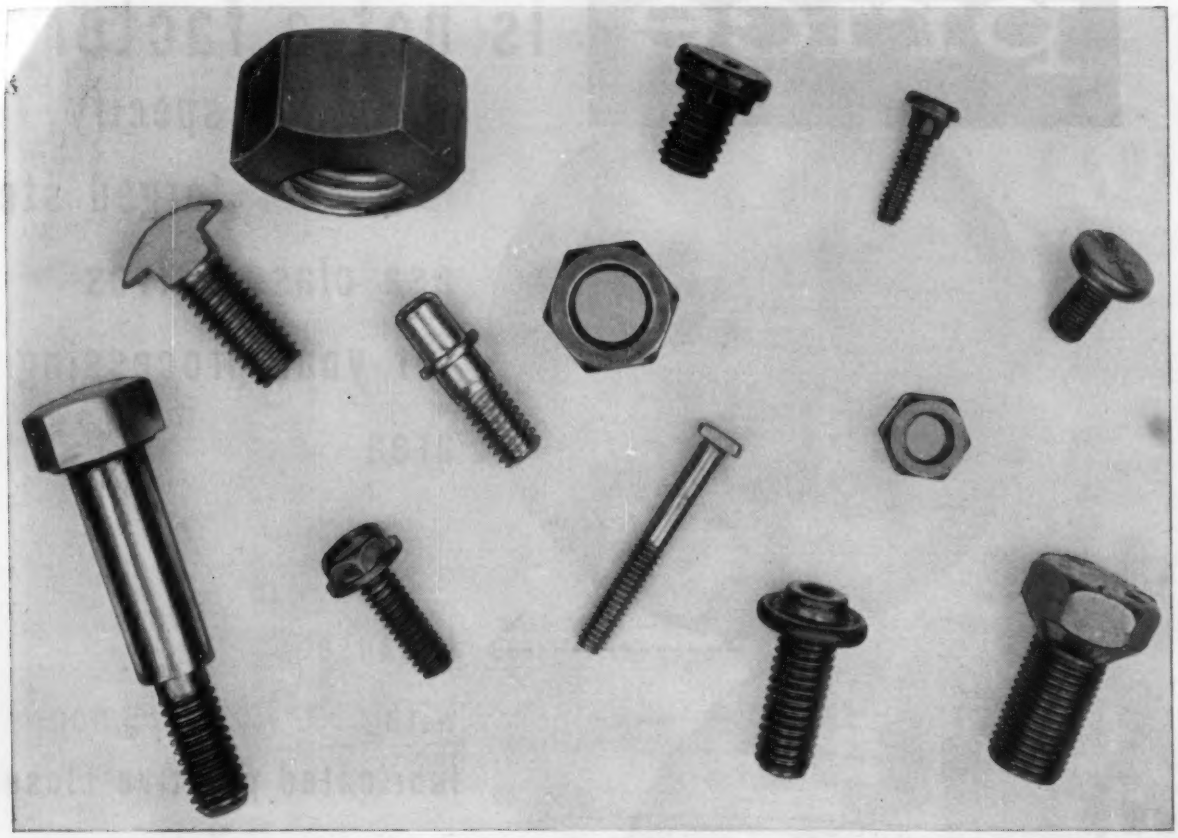
WEST COAST REPRESENTATIVE: Fred P. Koenig Company, Long Beach, Calif., 3815 Atlantic Avenue, GArfield 4-3834

CANADIAN REPRESENTATIVE: T. R. Pickford & Company, Ltd., Calgary, Alberta, 536 8th Avenue West, Phone 2-7371

EXPORT REPRESENTATIVE: New York 36, N. Y., 500 Fifth Avenue, BRyant 9-2236



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Get Dependable Service From SHEFFIELD

Need "something special" in bolts? Sheffield can come up with exactly what you need. Leastwise, we haven't had to say "no" on special bolts since 1888, when we started bolt making. At Sheffield there is a traditional pride of craftsmanship, specialized steel making and the newest in machines and facilities capable of taking care of any unusual special bolt assignment as smoothly as filling your standard bolt requirements.

Sheffield bolts and nuts are Sheffield-made from steel making to finished product in Mid-America's largest, most modern bolt-making plant... strategically located for fast, economical service to the Midwest, Southwest, Gulf and Pacific coasts.

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Bolt Products

The Only FULL LINE
Bolt Manufacturer
West of the Mississippi

THE SHEFFIELD LINE IS A **FULL** LINE

Sheffield makes thousands of standard and special bolts. Gives you the advantages of a complete line from a single source. Let us tell you more about it, and help you with any fastening problem. Get in touch with your nearest Sheffield district office now.

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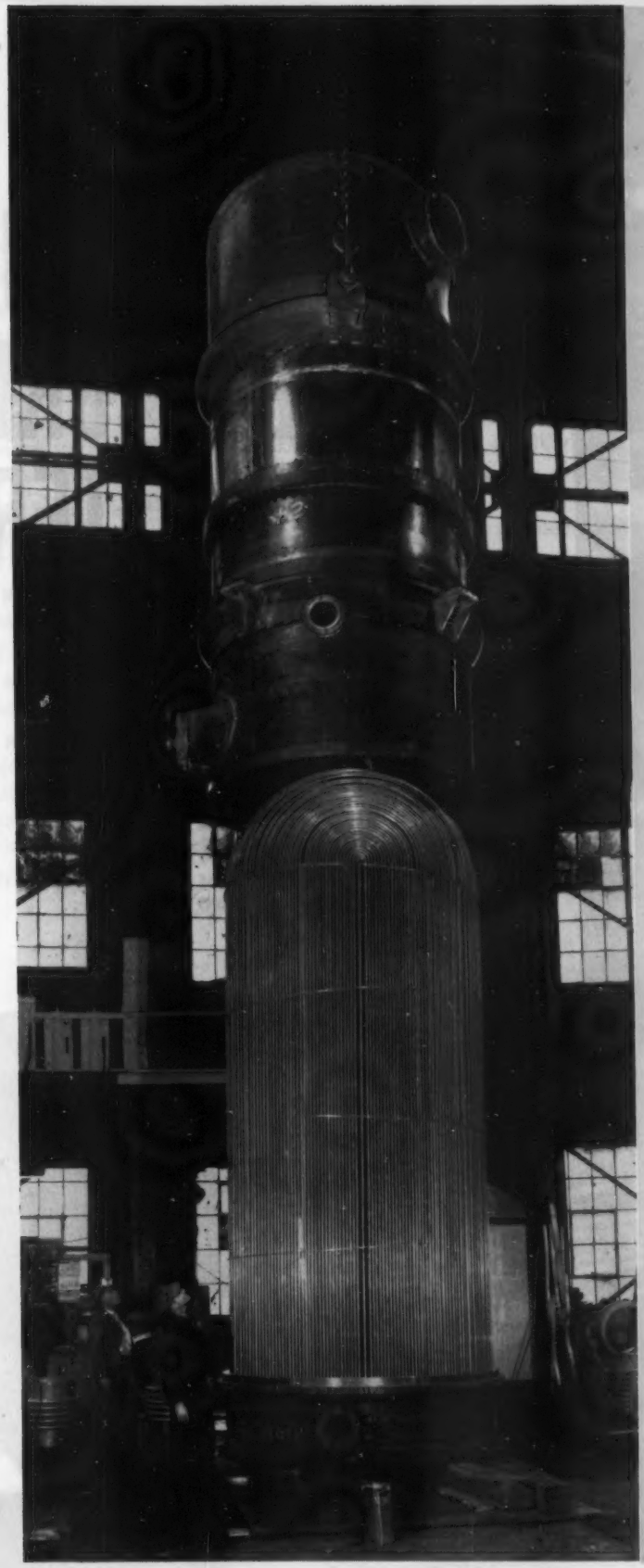

YUBA

A GREAT NEW NAME IN HEAT EXCHANGERS

▶ The name YUBA now appearing on heat exchangers all over the country is new. But the plants in Pennsylvania, New York and California which make YUBA heat exchangers are old in experience. Some have been designing and manufacturing heat transfer equipment for more than half a century.

For example, the YUBA Heat Transfer Division was formerly the Heat Exchanger Division of the world-famous Lummus Company; the Calsteel Division has established its own well-recognized name in the West; and the Adsco Division includes the former Alberger Heater Company.

YUBA's experience is, therefore, YUBA's assurance to its customers that the heat exchangers they order are expertly designed for required operating pressures and temperatures and for maximum heat transfer.

Take, for instance, the mammoth exchanger shown at the left, one of four built at the Buffalo Plant. The customer asked for a corrosion-resistant exchanger with tremendous capacity for a secret process. YUBA built this giant which weighs 50 tons, has 12¼ miles of tubing with 14,000 sq. ft. of heat transfer surface. The welding of the 16-ton copper silicon shell attracted industry-wide attention.

Consult YUBA when ordering heat exchangers and benefit from YUBA's vast experience and East-West facilities.

YUBA

CONSOLIDATED INDUSTRIES, INC.
New York Sales Office: 530 Fifth Avenue
Branch Offices and Representatives in Principal Cities

Divisions Manufacturing Heat Exchangers
Yuba Heat Transfer Division, Honesdale, Pa.
California Steel Products Division, Richmond, Cal.
Adsco Division, Buffalo, N. Y.

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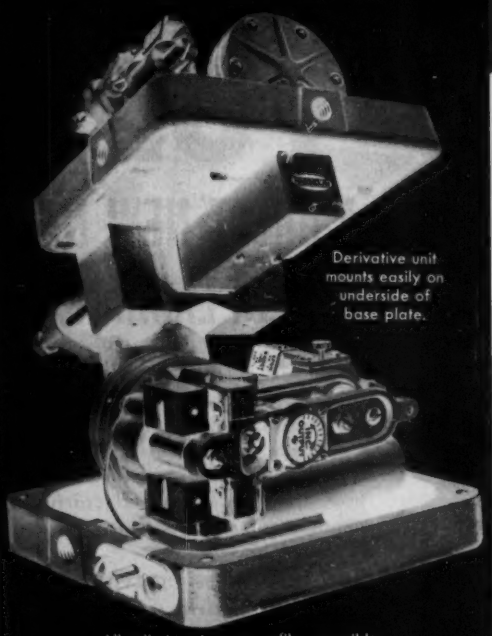
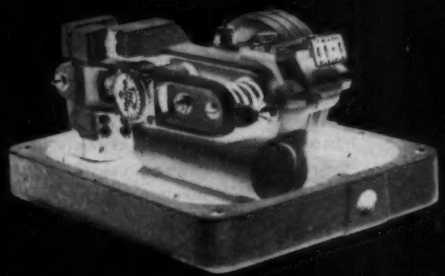
NEW



Derivative unit mounts easily on underside of base plate.

All adjustments are readily accessible, visible and easy to make.



Special "Balanced Beam" design permits mounting in any position without zero shift.

MASONEILAN TEMPERATURE TRANSMITTER

Distinguished by Exclusive Features

Important design differences in this newly developed force-balance transmitter offer advantages in accuracy and dependability. For example:

- **Balanced Beam** design permits mounting in any position without zero shift.
- **Unit subassembly** construction permits removal (for change of range, replacement or maintenance) of thermal system; compensating bellows; feedback bellows; pilot; range span adjustment assembly; derivative unit; gasketless nozzle — any or all without disassembling beam assembly in any way.
- **All adjustments visible and accessible** without disturbing any other part of the mechanism. Range span setting is unaffected by vibration.
- **Protection against damage** is provided for thermal system by a beam stop and the overrange feature; for compensating bellows by built-in stops; for entire unit by rugged weatherproof case.
- **Indicating Receiver Gauge** may be installed directly in manifolded base plate — no piping or tubing required.

A Pressure Transmitter, Too: The temperature transmitter may be readily converted to a pressure transmitter by substitution of a pressure element for the thermal system (within limits imposed by pressure conditions and characteristics of measured fluid).

Write for bulletin or secure details from our nearest office.

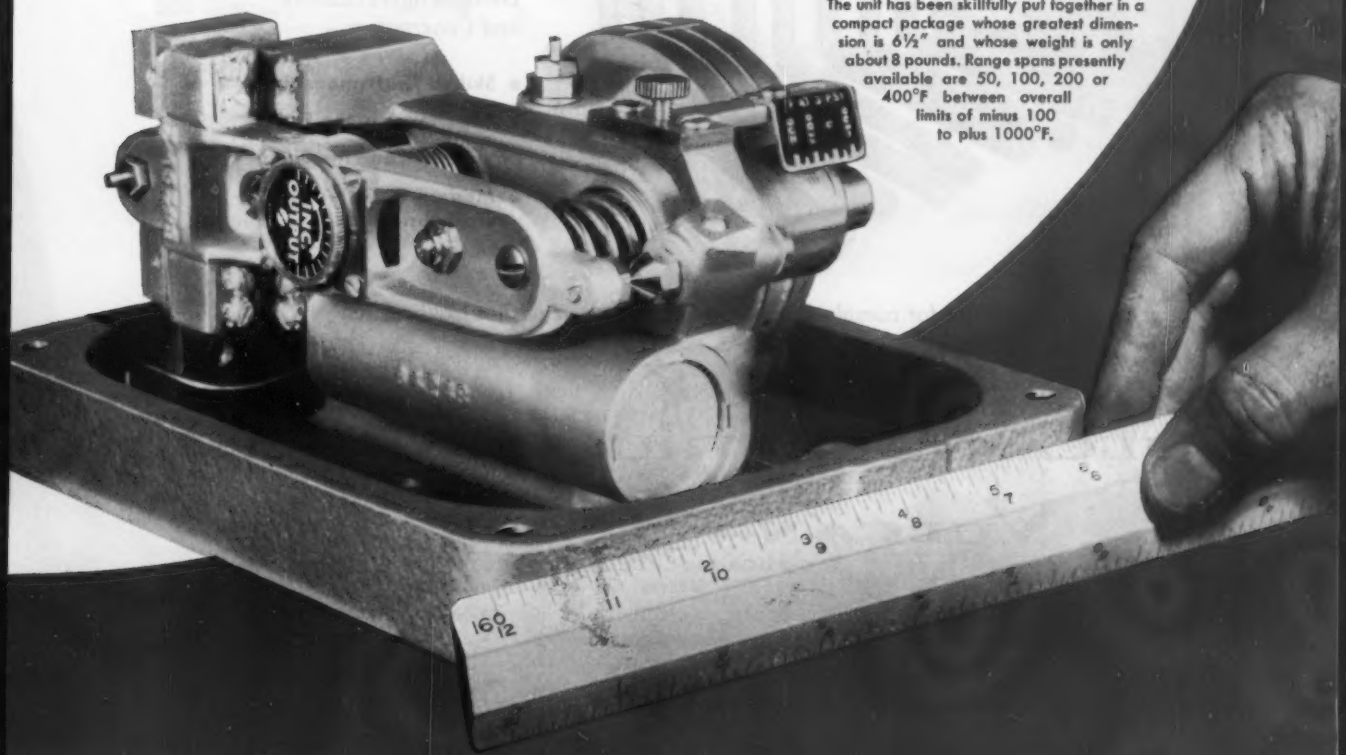
MASONEILAN

MASON-NEILAN

Division of Worthington Corporation

51 NAHATAN STREET, NORWOOD, MASSACHUSETTS

SEVENTY-FIFTH 75 ANNIVERSARY



The unit has been skillfully put together in a compact package whose greatest dimension is 6½" and whose weight is only about 8 pounds. Range spans presently available are 50, 100, 200 or 400°F between overall limits of minus 100 to plus 1000°F.

Fabricated Piping...

Vulcan operates integrated and highly specialized plant facilities for the fabrication of copper and special alloy piping—ranging from the simplest to the most complex type of assembly. Complete facilities are available for pickling, passivating and testing prefabricated piping. All work is performed according to ASME, API—ASME and ASA codes.

Vulcan Construction Division offers Owners and Contractors –

- **Skilled Craftsmanship**
- **Experience in the Field**
- **Experience in the Shop**
- **Modern Facilities for Piping Fabrication**

Write for complete or specific information without obligation.

VULCAN CONSTRUCTION DIVISION

VULCAN—Cincinnati, Inc.
General Offices and Plant, CINCINNATI 2, OHIO
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CONTRACT ENGINEERING with a difference

from initial negotiations . . . to "on stream" you deal with Badger principals

You first make contact with Badger through a Key Man as he works with you and your engineering staff in pinpointing your processing and economic problems.

The Key Man, acting in your behalf, takes your problem to Badger engineering specialists for preliminary study and evaluation.

With recommendations approved and construction underway, the Badger Key Man is still on the spot coordinating activities. He remains in charge until your project is complete.

AN engineering project handled by Badger is a group effort involving many highly developed skills. And from first contact until the project is complete these experienced specialists are headed by a Badger Key Man. More than just a sales engineer, he is always a Badger principal — always the Key Man in the execution of the project.

This sensible operating policy, which channels project liaison, coordination and administration through a company principal, is important to you and your project. You will find that most policy level decisions can be made on the spot as situations require. Further, the Key Man's depth of experience means you deal with an executive-engineer who talks your language — knows your problems and how to find their solutions.

Many clients say Key Man Policy is the Badger difference that makes the difference. Wouldn't it be wise to inquire how it could serve to make your projects more successful?

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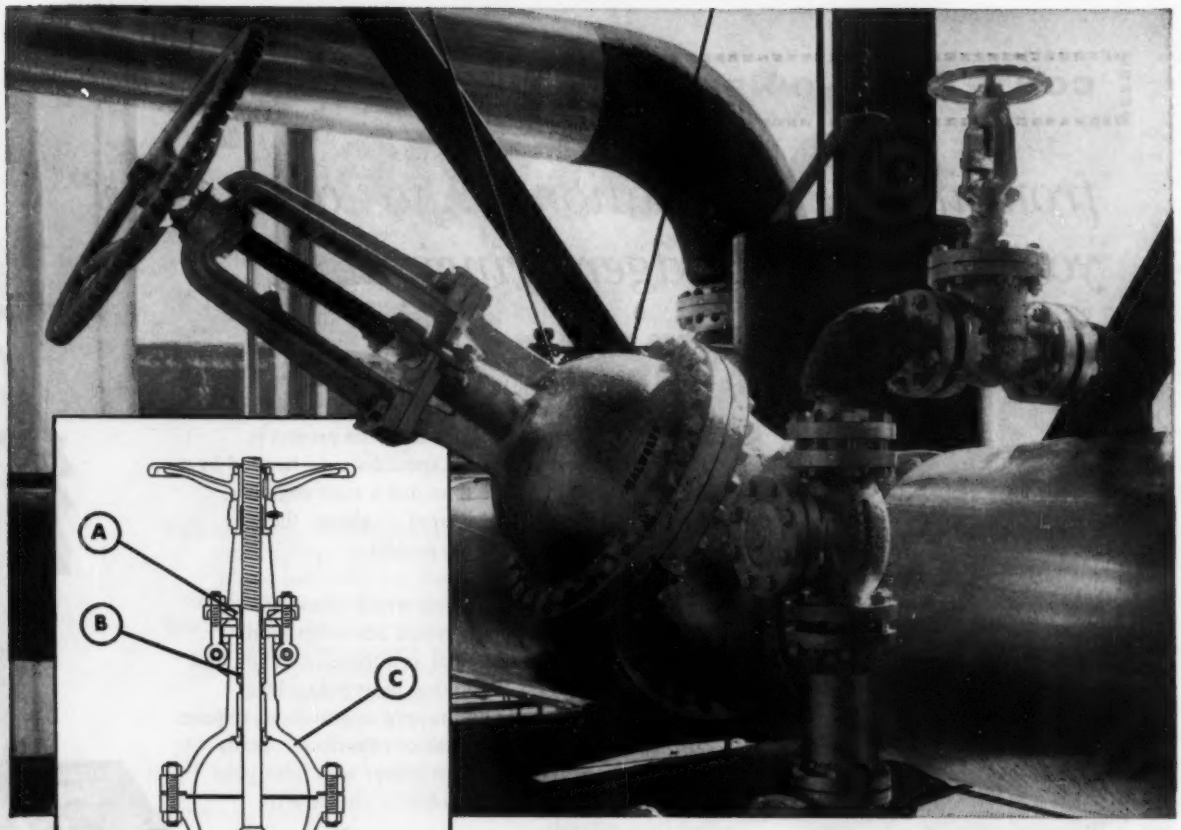

Walworth Series 150 and 300

CAST STEEL GATE VALVES OFFER YOU THESE FEATURES

for 'round-the-plant service

(A) GLANDS: Clearances between the gland and stuffing box, and gland and stem, are such that the stem cannot be scored even if the gland is pulled down unevenly.

(B) DEEP STUFFING BOXES: More than adequate in all sizes (2″ to 24″) to assure tightness and maximum packing life.

(C) BONNETS AND BODIES: Engineered to exceed the requirements of all applicable codes and standards. They are tough, durable, dependable.

(D) INTEGRAL GUIDE RIB FACES IN BODY: Machined to insure accurate centering of the gate.

(E) STURDY SEAT RINGS: Bottom-seated so that no recess exists at the back of the ring to cause turbulence, erosion and pressure drop.

(F) STREAMLINED PORTS: Permit unobstructed flow which results in minimum pressure drop and reduces the possibility of erosion.

Walworth Cast Steel Gate Valves can be furnished with either flanged ends or butt welding ends. Roller bearing yokes are available on the larger sizes. On valves 4 inches and larger, by-passes can be furnished. Walworth Cast Steel Gate, Globe and Check Valves from Series 150 to 2500, are available. For Series 600 and higher, we recommend Walworth Pressure Seal Cast Steel Valves. See your Walworth Distributor or write to Walworth for complete information.

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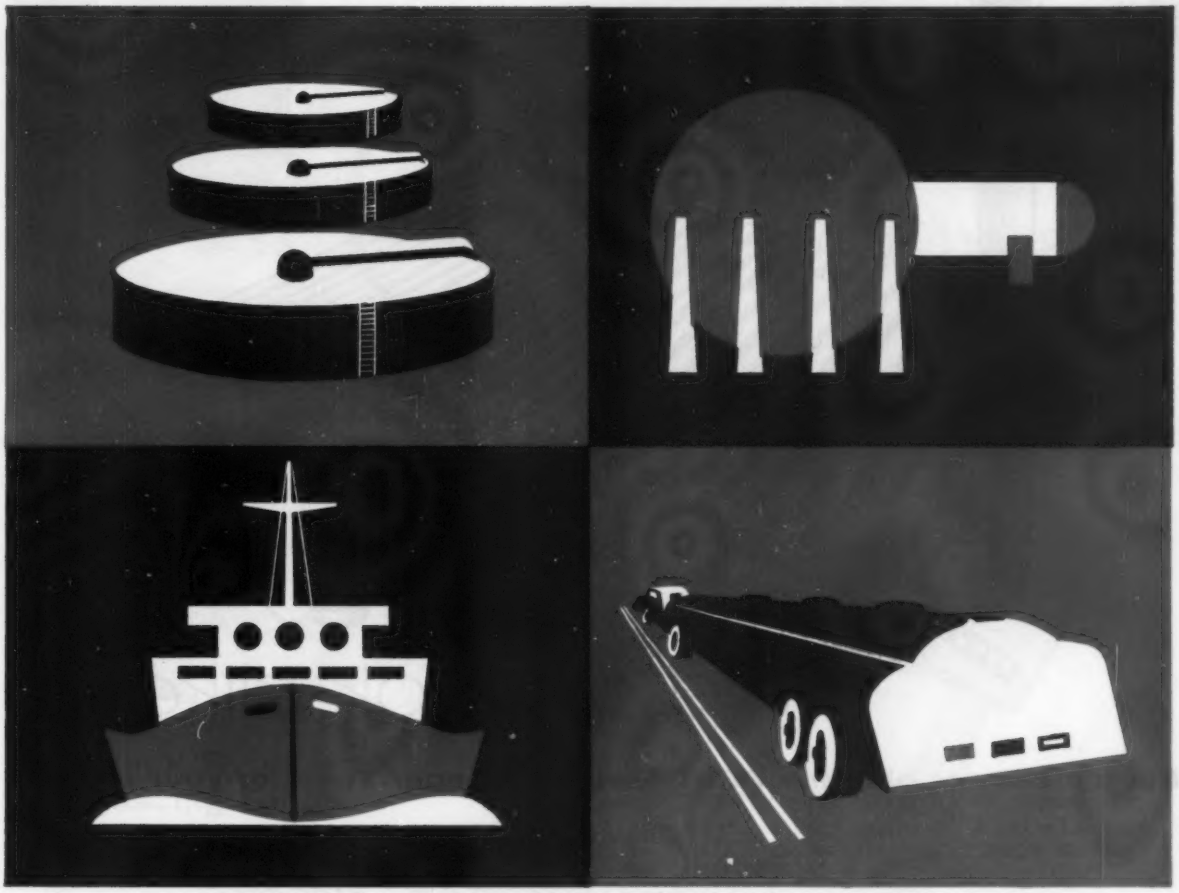

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Only Shand and Jurs offers world-wide availability and service on mechanical fittings — vents, gages and valves — for storage tanks. Stocks are maintained in key cities for prompt delivery to your tank farm, yard or depot.

Proved by over 36 years service, S&J tank fittings have set the industry standard for economy, safety, accuracy and dependability. Call or write your nearest S&J office for catalog and prices on the type of fittings you need.

S&J is also a world-leader in the manufacture of electrical remote supervisory control equipment.

SHAND AND JURS CO.
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sure
they all look alike...

but it's easy to pick the BEST Heat Exchanger Tube for your job...

Like many "specification" products, different brands of heat exchanger tube may look alike . . . yet still show wide variation in performance.

A great many factors are involved, from uniform chemical composition and inherently sound metal in the alloy to the condition of surface finish on the tube.

One sure way to save time and trouble is to "put it up to Scovill." Scovill Technical Service is one of the most experienced in the field, with a long record of successful applications. Unique Scovill production advances, such as Continuous Casting (of Phosphorized Admiralty), are plus values that cost you no more . . . yet surely pay out in tube performance.

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99 Mill Street, Waterbury 20, Connecticut.
Phone Plaza 4-1171.

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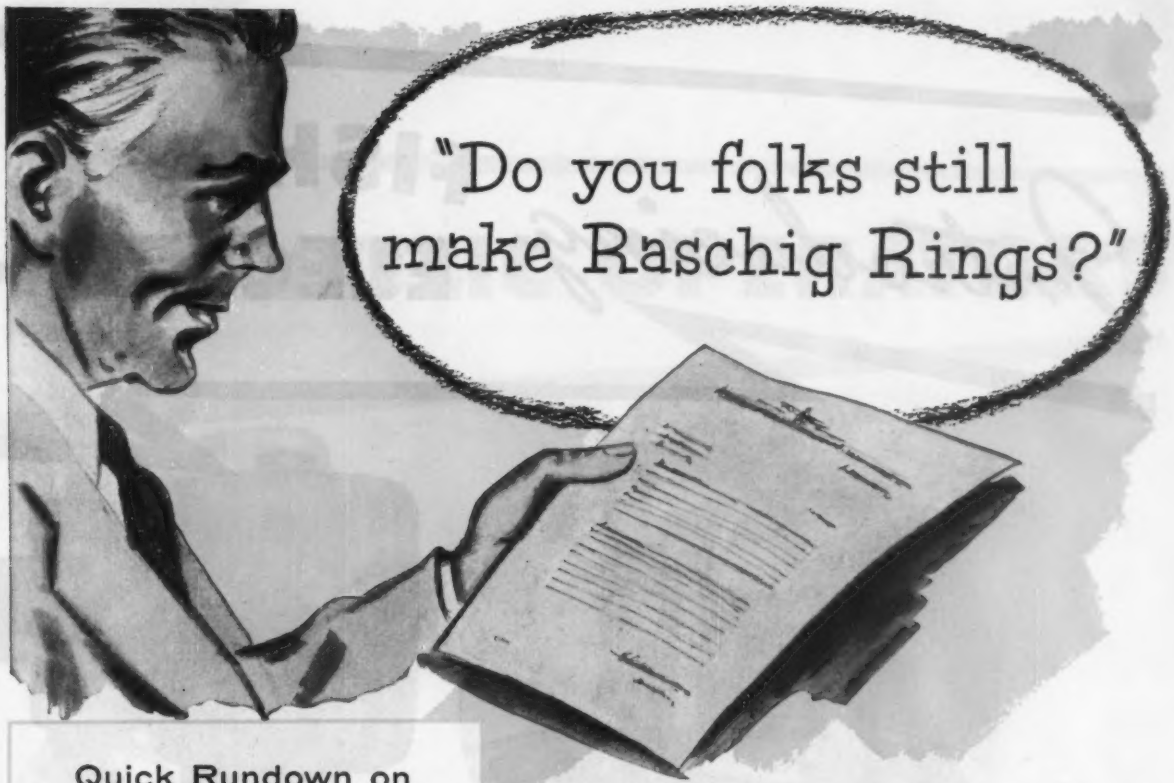

Quick Rundown on Raschig Rings:

Ceramic: We make them both in chemical stoneware and in white chemical porcelain in some sixteen sizes from ¼" O.D. to 6" O.D. — in standard or heavy wall.

Carbon: Eight sizes from ¼" O.D. to 3" O.D. These rings are all carbon, no soluble filler is used. Light, strong, resistant to severe thermal shock.

Metal: Available in fifteen sizes from ¼" O.D. to 3" O.D. in carbon steel, stainless steel and aluminum.

We'll admit the letter gave us a bit of a start. It went on to say: "In the last half dozen years all I've heard has been 'Intalox Saddles' . . . 'Intalox Saddles' . . . 'Intalox Saddles' . . . how much more efficient they are than rings. Can't I buy plain old-fashioned Raschig Rings any more?"

Sure, you can — and they're better than ever. As a matter of fact, we made and sold more Raschig Rings last year than ever in our history—more, even, than any other company in the business. Admittedly they don't measure up to Intalox Saddles or the newer metallic Pall Rings in performance — but many times the extra performance characteristics of the newer packings aren't needed, and the lower price of Raschig Rings makes them definitely worth using.

And there are new developments in Raschig Rings, too. In ceramics, the porcelain bodies are stronger, more resistant to spalling, possess better thermal shock properties. We have special bodies for better performance with alkalies. We make them in larger sizes, even up to six inches. And, of course, our porcelain bodies are completely iron-free, and show zero-absorption.

Yes — when the economics of the application indicate Raschig Rings — your one best source is, as always — U. S. Stoneware.

89F

Visit Booth 111
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New Tower Packing Catalog

Complete data on all Tower Packings of our manufacture. Free on request.

U. S. STONEWARE
AKRON 9, OHIO

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Introducing FISHER ELECTRO-

Recent trends toward electrical control loops have created a need for final control elements capable of utilizing their greater sensitivity and speed. Fisher Electro-Hydraulic Operators are self-contained, electrically operated valve actuators, ideal for use in such control loops. They produce high performance without the use of electronic amplification, utilizing only a simple DC electrical circuit to control the hydraulic pilot. The pilot systems incorporate no close fitting parts, but use simple nozzle-flapper combinations to control hydraulic pressure.

Two sizes are available. To handle the most demanding control jobs Type 350 has a maximum stem thrust of 2000 pounds and is available for use on valve sizes ½″ to 16″ with strokes from ½″ to 3″. Type 340 is designed for the average control job. It has a maximum stem thrust of 600 pounds and is available for use on valve sizes ½″ to 4″ with strokes from 7/16″ to 1½″.

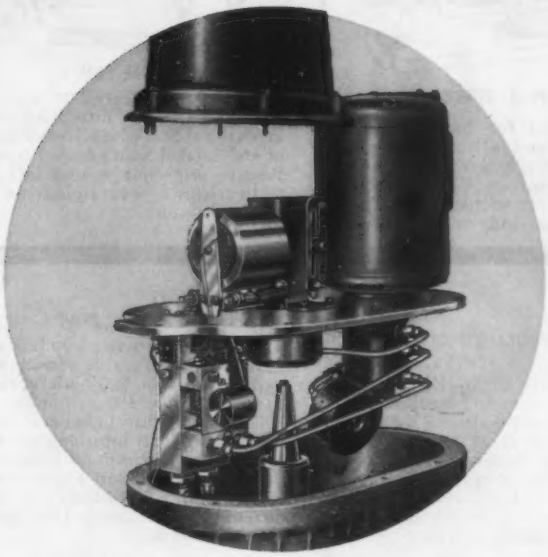
Rugged, simple design plus accurate, dependable performance, make the FISHER Electro-Hydraulic Operators the outstanding electric final control elements available.

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND

FISHER GOVERNOR COMPANY

HYDRAULIC OPERATORS

TYPE 350



LIQUID LEVEL CONTROL

TYPE 340	TYPE 350
• Adaptable to all DC output signals	• Adaptable to all DC output signals
• Requires only zero and travel adjustment (both readily accessible)	• Requires only zero and travel adjustment (both readily accessible)
• Stroking range from 7/16" to 1½"	• Stroking range from ½" to 3"
• Stroking speed 0.1"/sec.	• Stroking speed 0.37"/sec.
• Resolution sensitivity—0.2% of input range	• Resolution sensitivity—Better than 0.05% of input range
• Maximum stem thrust 600 pounds	• Maximum stem thrust 2000 pounds
• Operates on simple DC—no electronic amplification	• Operates on simple DC—no electronic amplification
• Valve sizes from ½" to 4"	Valve sizes from ½" to 16"

FISHER® Controls

SINCE 1880

Marshalltown, Iowa / Woodstock, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

BJ

pumps and mechanical seals for refineries

For special engineering assistance or for further information about Byron Jackson pumps and mechanical seals, contact your nearby BJ sales office or write Byron Jackson Pumps, Inc., P.O. Box 2017 Terminal Annex, Los Angeles 54, Calif.

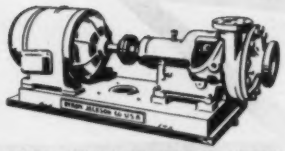
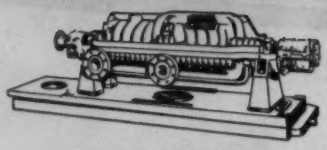


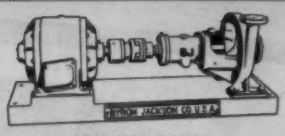
FIGURE 1025-1125 PROCESS PUMPS

Moderately priced pumps for general-purpose handling. Available with BJ Mechanical Seal. Capacities to 2000 gpm, heads to 800 ft. Temperature limit 350°F. Write for Bulletin 353-300.



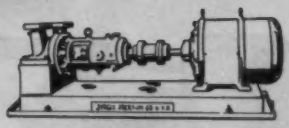
MULTIPLEX PUMPS

Recommended for boiler feed, debarking and all classes of medium-to-high pressure and temperature service. Easy inspection or cleaning without disturbing piping, bearings or driver.



CHEMICAL PUMPS

Specially engineered to handle corrosive liquids. Fitted with BJ Mechanical Seal with all major parts of seal isolated from pumped liquid. Positive protection against leakage to bearings or contamination of pumped liquid.



SM PROCESS PUMPS

For pumping fluids over a wide range of pressures and for temperatures up to 800° F. Ideal for pumping hot or cold liquids near their vapor pressure. Capacities to 4500 gpm and heads to 1900 ft.

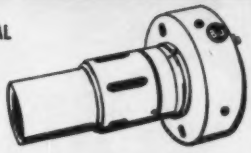
VERTICAL CIRCULATING PUMPS

Single or multi-stage. For pumping medium to high capacities of water. Capacities to 50,000 gpm. Saves space, simplifies piping. For dewatering, drainage, river intake, circulating and sump services.

SMI PROCESS PUMP

This general purpose pump features a BJ mechanical seal as a functional part of its design. It is built for continuous duty and temperatures to 400°F. Easily dismantled and reassembled without disturbing suction or discharge connections. Construction materials to suit application. Sizes: 1½ thru 6" suction, 1 thru 4" discharge. Capacities to 1500 gpm. Heads to 700 ft.

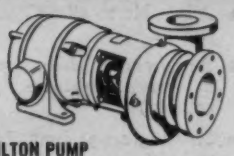
MECHANICAL SEALS



Replace standard packing in stuffingboxes. Eliminate excessive leakage and frequent repacking. Recommended for corrosive, high temperature or volatile liquid pumping. Prevent contamination of pumped liquid.

DOUBLE SUCTION HOT OIL PUMP

Developed for capacities beyond the range of single suction process pumps. Designed to handle high temperature liquids on continuous service operation. Rotating element can be removed as a unit without disturbing the piping or driver. Capacity range from 1000 to 7000 gpm, heads from 100 to 700 feet. Construction materials to suit application.



BILTON PUMP

A general-purpose, close-coupled pump and motor unit. Mounts in any position with no rigid base needed. Especially useful where space is limited. Available with explosion-proof motor. One-third to sixty hp. Capacities to 2000 gpm and heads to 475 ft.

TYPE VMT PUMP

May be designed for pumping liquids from sub-zero to 750° F.—corrosive or non-corrosive—where NPSH is limited. Capacities to 9000 gpm and heads to 575 ft. Smaller standardized (VLT) models also available in capacities to 240 gpm.

SUBMERSIBLE PUMPS

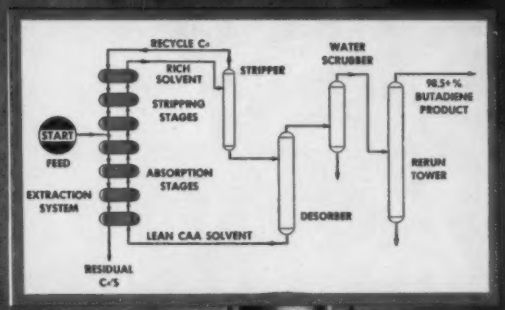
For well pumping, booster stations, or for standby service. Pump and sealed motor operate completely submerged. No pump house or surface structure needed. No well too deep. Ideal where flood menace exists. Capacities to 20,000 gpm and heads to 1800 ft. Write for Bulletins 55-2-700 and 55-3-700.

HYDROPRESS PUMPS

For medium to high pressure pumping at low capacity. Vertical construction saves space, simplifies installation. No relief valves required. Uniform nonpulsating flow. Capacities to 600 gpm. Heads to 10,000 ft.

LIQUID OXYGEN PUMP

Handles liquid oxygen or nitrogen at temperatures as low as –300°F. Insulated section between pump and stuffingbox keeps leakage to a minimum. Standard capacities to 1500 gpm. Heads to 4000 ft. Greater requirements possible by special design.



50,000 TONS PER YEAR BUTADIENE EXTRACTION UNIT OF HUMBLE OIL & REFINING COMPANY, BAYTOWN, TEXAS

CAA BUTADIENE EXTRACTION CAN GIVE YOU LOWEST OPERATING COSTS

Esso Research and Engineering Company offers you the most economical *Butadiene Extraction Process* ever developed, with a high recovery rate and high purity of product.

Superior service factor, elimination of corrosion and waste disposal problems, and low utility requirements of the *CAA Process*, demonstrated in years of commercial operation, mark it as another achievement of Esso Research — 38 years of process developments made available to refiners around the world.

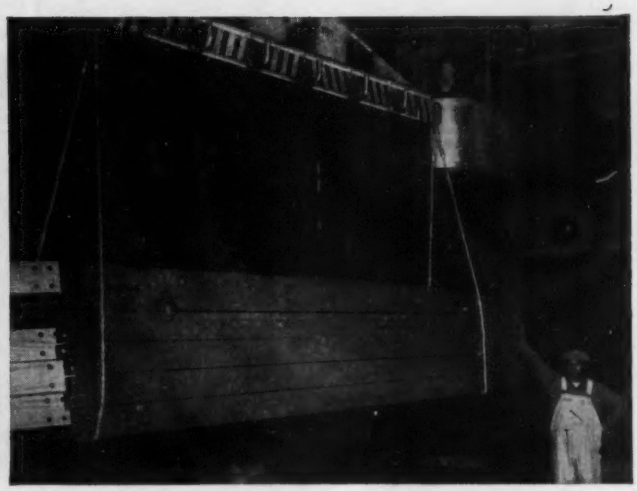
High purity butadiene, now used principally in synthetic rubber production, has a growing value as a chemical intermediate. The cuprous ammonium acetate solvent (CAA) permits a higher recovery of 98.5+% purity butadiene than any other extraction process.

Licensees enjoy benefits of new *CAA* process developments. We would welcome your inquiry on the part this important process can play in *your* expansion plans.

ESSO RESEARCH AND ENGINEERING COMPANY

15 West 51st Street, New York 19, N. Y.

Your key to progress... an Esso Research process



BUILDINGS AWEIGH! One of the nation's largest makers of prefabricated steel buildings speeds up production with Tuffy Slings. High flexibility makes Tuffy Slings conform perfectly to irregularly shaped load contours and sharp corners, and snug down smoothly in a choker hitch. Handling and rigging time is cut to the bone. Photographs show heavy loads of steel sheathing panels and steel structural members of prefabricated buildings being handled by Tuffy Slings.

Extra Strength Teams Up With Extra Flexibility in Tuffy® Slings for Fastest Handling of Heavy Loads

How Tuffy Took the Cussedness Out of Slings

Regular-construction wire rope such as the 6x19 or 6x37 will give you the strength you need in sling work. But it makes an ornery kind of sling—stiff to handle, quick to kink and loop, subject to serious damage when bent around small radii and sharp corners.

Tuffy Slings are a different story. They behave beautifully—because they combine the strength of steel with the flexibility of a smooth-flowing fabric. Yet with all this tranquility of disposition, you can't beat Tuffy for taking shock and impact loads.

It's Almost Impossible to Kink a Tuffy Sling. Try it!

With the help of a vise, you might succeed. But you'll find the kink smooths out with hardly a trace of damage. Tuffy's machine-braided fabric won't take a "set" or deformity under the toughest of ordinary working conditions.

Get your FREE Tuffy Sling Handbook

Gives full data on Tuffy Sling types, dimensions, weights and rated loads. Plus a complete rigger's manual and engineer's notebook on wire rope constructions and specifications. Write for your copy now.

Tuffy Pressed-On Ferrule Gives Eye-Splice Full Fabric Strength

Applied under tremendous pressure, the steel ferrule literally flows into every space between wires and strands. The friction force created gives the eye splice 100% of fabric strength. And the streamlined Tuffy ferrule leaves no openings or rough projections to snag or injure hands.

"Double the Service Life of Ordinary Slings..."

That's what one of the nation's big steel corporations reports on the use of Tuffy Slings in their mills. We have a growing stack of similar testimonials from every area of industry where Tuffy Slings and Hoist Lines are used.

Your Tuffy Distributor is a Good Man to Know

He'll help you save money with the longer trouble-free life of Tuffy Slings. He's always ready with what you need—the exact Tuffy Sling or Union Wire Rope for your requirements. He's not only well-stocked for your scheduled-replacement or emergency orders; he's backed by his nearby Union Wire Rope mill depot.

union Wire Rope **corp.**

Specialists in high-carbon wire, wire rope, braided wire fabric, and stress-relieved wire and strand. (5)

2284 Manchester Avenue **Kansas City 26, Missouri**

TRUFIN EASY TO USE WHEN RETUBING UNITS

An outstanding feature of Wolverine Trufin is the ease with which it can be substituted for plain tube during retubing operations. In manufacturing, Trufin's ends are left plain. Each end has a heavy wall section which is approximately two gauges heavier than the finned portion of the tube. Result: greater rolling or brazing flexibility at the header. The heavy ends also provide greater protection against inlet erosion.

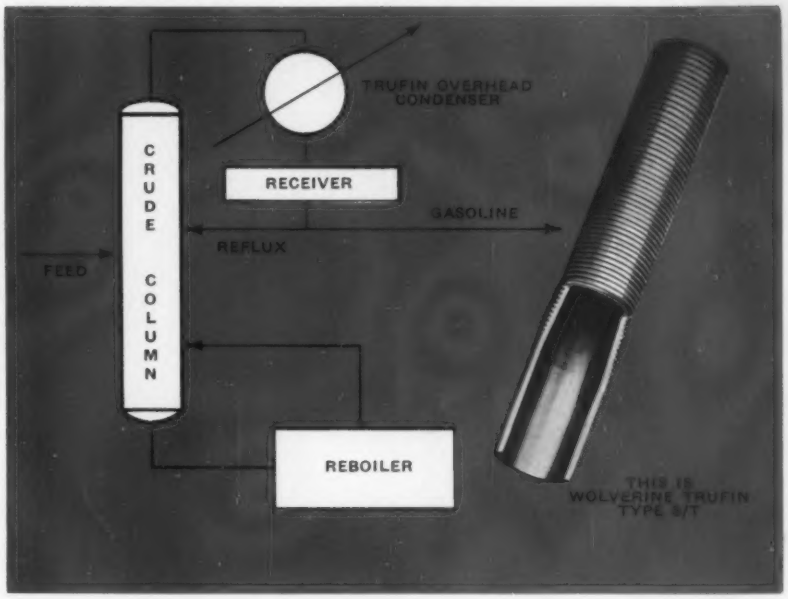
WOLVERINE TRUFIN CUTS DESIGN COSTS

Heat exchangers and condensers designed around Wolverine Trufin Type S/T, can in many cases, be fabricated more economically than with plain tube.

The use of Trufin—with its extended surface—for example, can reduce the number of lineal feet of tubing required to obtain a given heat duty. Fewer tubes mean, in turn, smaller shells, baffles and headers plus a substantial savings in labor. If the unit is to be used in overhead service there is also a saving in the amount of material normally required for superstructures.

NEW BOOK OFFERS COST COMPARISONS

Direct cost comparisons between the use of Wolverine Trufin and prime surface condenser tubing in heat transfer applications are given in Wolverine's new book "Comparative Heat Exchanger Costs." Just off the press, this new book contains valuable information—should be in the reference file of every processing engineer. Write today for your copy.



Retubing Does The Trick:

INTEGRALLY FINNED TUBE BOOSTS DEPROPANIZER CONDENSER OUTPUT

BY ERNEST DODD

Up until recently, in heat transfer work, a refinery engineer didn't have much choice when he wanted to increase heat duty. He could design a bigger unit—with increased surface area—or he could add another unit to those already on stream—providing of course, that he had sufficient room.

Well, it isn't that way anymore.

Nowadays—thanks to Wolverine Trufin® Type S/T—the refinery engineer can increase heat duty simply by retubing with integrally finned Trufin Type S/T. This is exactly what engineers at a west coast refinery did when they needed increased heat duty from an overhead depropanizer condenser on their fluid catalytic cracking unit.

After Trufin Type S/T—446 pieces, 16-feet long to be exact—had been substituted for the plain tube bundle, the initial boost in heat duty was 48%—a highly gratifying figure to all concerned. But that wasn't all.

During its days as a plain tube unit, this condenser had to be taken off stream for frequent cleanings. With Trufin Type S/T in the bundle, the unit has been in production for a full year without requiring cleaning—the first time this has ever happened.

Naturally there's a logical reason for this improved performance.

Wolverine Trufin Type S/T is an extended surface tube—gets its increased surface area from its integral fins which are actually squeezed from the tube wall. Because of this, Trufin has approximately 2½ times more surface area than does an equivalent piece of plain tube. Percentage wise this is an increase of 150%. It is this increased surface area that permits Trufin Type S/T to extract more BTU's per foot of tube.

Tests and authenticated case histories show that when Trufin fouls, the scale buildup follows the fin profile instead of preferring the valleys between the fins. Because Trufin does not present a flat surface, there is a tendency for the scale to fall away—which explains why Wolverine Trufin resists fouling and stays on stream for longer periods than prime surface tube.

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SALES OFFICES IN PRINCIPAL CITIES
EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK
Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario.

FINNED TUBE BOOKS AVAILABLE—FREE!

Wolverine Tube, from its years of experience, has compiled and published literature of great interest to those engaged in heat transfer work. Among its catalogs and booklets are the COMPARATIVE HEAT EXCHANGER COSTS BOOK, TRUFIN CATALOG, CONDENSER TUBE CATALOG, PROCESS FLOW SHEET BOOK, WOLVERINE CORROSION CHART and the TRUFIN WATER HEATER BOOK. Any—or all—of these are yours—FREE. Why not write TODAY.

We've Been Asked:

WHEN TALKING OF WOLVERINE TRUFIN® WHAT DO YOU MEAN BY TYPE S/T?

BY ERNEST DODD

In addition to pioneering in the development of integrally-finned condenser tube, Wolverine Tube has also been responsible for coining the various designations used to describe different types of integrally finned tubing. Because of the increasing popularity of Wolverine Trufin®, we are often asked to explain just what these designations mean.

Actually, Wolverine Trufin is available in six different types—each designed for use in specific heat transfer applications. The most widely used is Trufin Type S/T named by Wolverine to identify its use in shell and tube condensers. Trufin Type S/T is a low finned tube with either 16 or 19 fins per inch (depending on alloy). The ratio of outside-to-inside surface area is approximately 3.75 to 1.

Wolverine also produces Trufin Type W/H, so named because it was designed primarily for use in water heaters. Trufin Type W/H is a high finned tube with 11 fins per inch. It has an outside-to-inside surface ratio of approximately 4.75 to 1.

To help the processing industry do a better hydrocarbon cooling job Wolverine developed an all-aluminum Trufin tube with integral fins on the outside and longitudinal fins on the inside. This tube is called Trufin Type I/L (internal longitudinal). It is available with 5, 7, 9, or 11 fins on the outside and has sufficient fins on the inside to approximately double the surface area. In addition to hydrocarbon cooling, Trufin Type I/L is also ideal for air cooling oil or in air-type refrigeration evaporators.

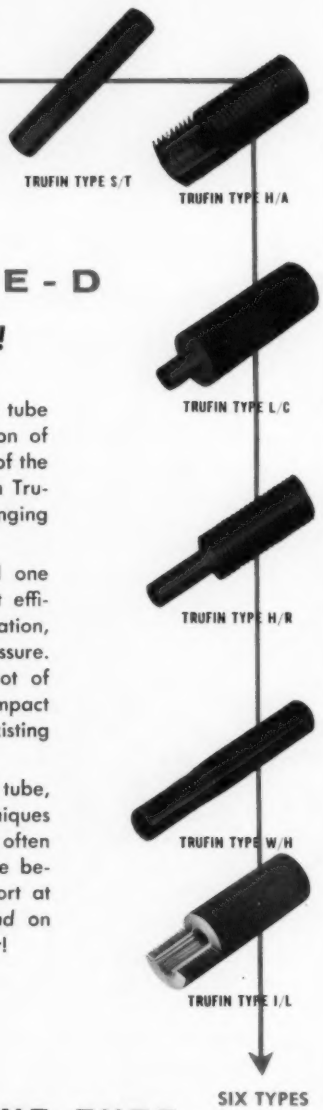
Trufin Type L/C is a high finned-lightweight aluminum tube mechanically bonded to an interior liner of any metal. Type L/C was designed to economically provide an extended surface tube with a liner core permitting adaptation to a variety of corrosion and/or pressure requirements. Type L/C, too, is ideal for air-cooled operations.

To facilitate insert type end connections by brazing, Wolverine developed an extended surface tubing with a controlled inside diameter—named it Trufin Type H/A (high area). Trufin Type H/A is a high finned tube with an outside-to-inside surface ratio of approximately 8:1. Air or gas flows outside the tube to be heated or cooled. The condensing or evaporating liquid is passed through the inside of the tube.

Finally there's Trufin Type H/R (high root)—similar to Type H/A. The root diameter is closely controlled and sufficient wall thickness allowed to permit the removal of fins for rolling into tube sheets. Type H/R is a high finned tube—has an outside-to-inside surface ratio of approximately 8:1.

And there, briefly, is a look into the background of integrally finned condenser tubing—a Wolverine development that is becoming more and more important with the passing of each day.

LOOK



FINS actually

E-X-T-R-U-D-E-D

from the tube wall!

The fact that its fins are part of the tube wall is the secret of the construction of Wolverine Trufin. It's the secret too, of the amazing performance records which Trufin-tubed heat exchange units are hanging up every day.

Because the fins and tube are all one piece, you are assured of constant efficiency. Fins are not impaired by vibration, temperature change or varying pressure. Trufin transfers *more* BTU's per foot of tube—permits you to design more compact units—steps up the capacity of existing ones.

Trufin is fabricated as easily as plain tube, too. In fact, standard tools and techniques are used. Fabricated Trufin units are often stronger than units using plain tube because fins provide additional support at bends. Remember: You can *depend* on Trufin for *dependable* heat transfer!

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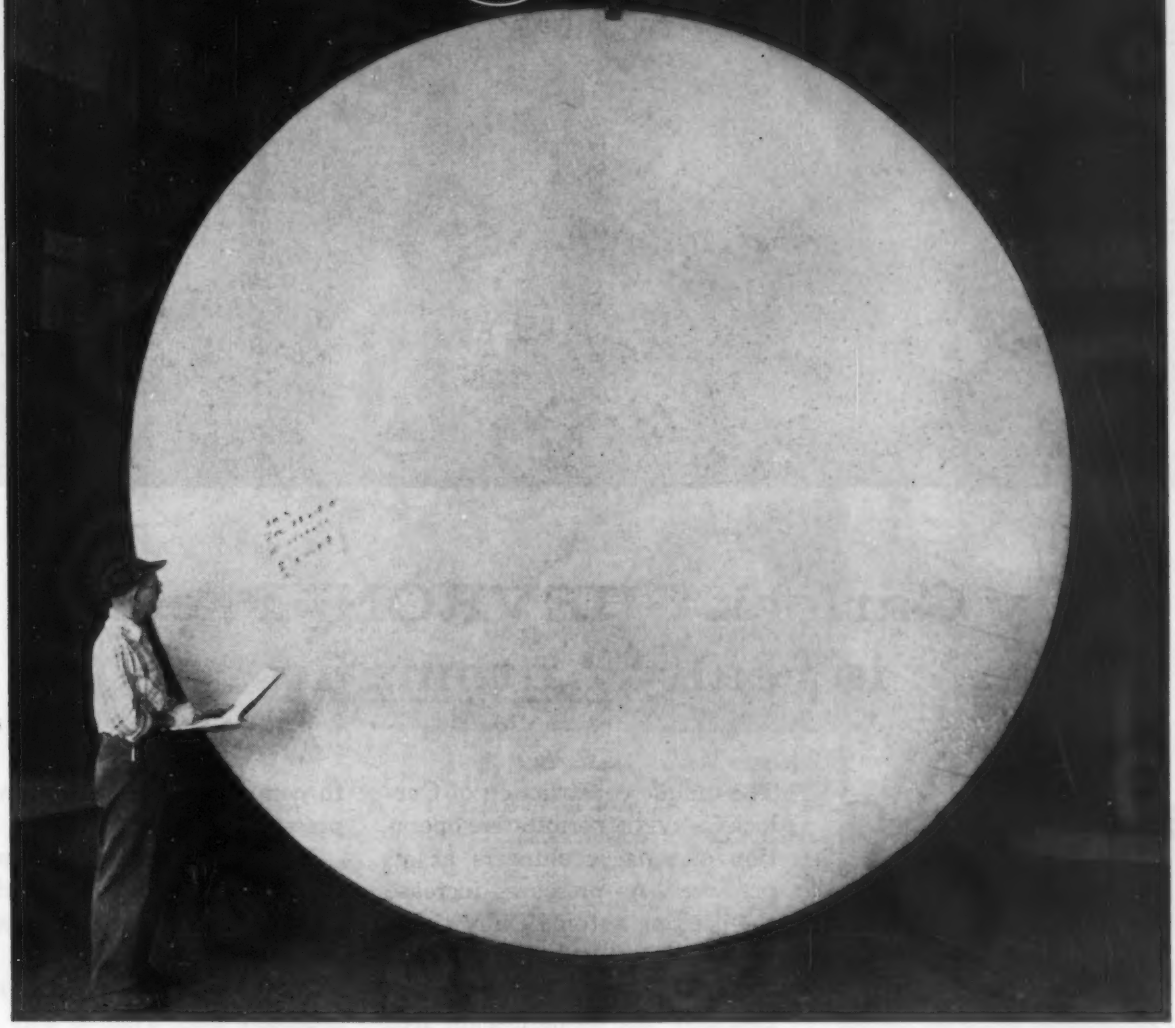
WHY BUY STAINLESS STEEL squares WHEN IT'S circles YOU NEED?



This circle, 9/16" thick x 164" diameter, is one piece of Type 316L stainless steel. Had the customer ordered a square, he would have paid freight on a half-ton of excess material. Also, he would have had the problem and expense of handling the square and cutting the circle.

Here are four sound reasons why Carlson customers save time and money when they order the circles they want—rather than the squares they have to cut . . .

1. If the gauge and size are circle-shearable, there is no extra charge for cutting the circle. This saves cutting labor and scrap handling expense.
2. If the gauge is such that a cutting charge applies to the square, it pays to order the circle. This eliminates the extra charge for cutting the original square and involves only the one charge for cutting the circle.
3. Because circles weigh approximately 25% less than squares, there's a substantial saving in transportation costs.
4. Small or medium size circles are often available from stock when squares may not be. The delivery time saved can be an important factor.

When you need stainless steel circles, come to Carlson where we specialize in stainless steel . . . that's your guarantee of dependable service.

Stainless Steels Exclusively

G. O. CARLSON Inc.

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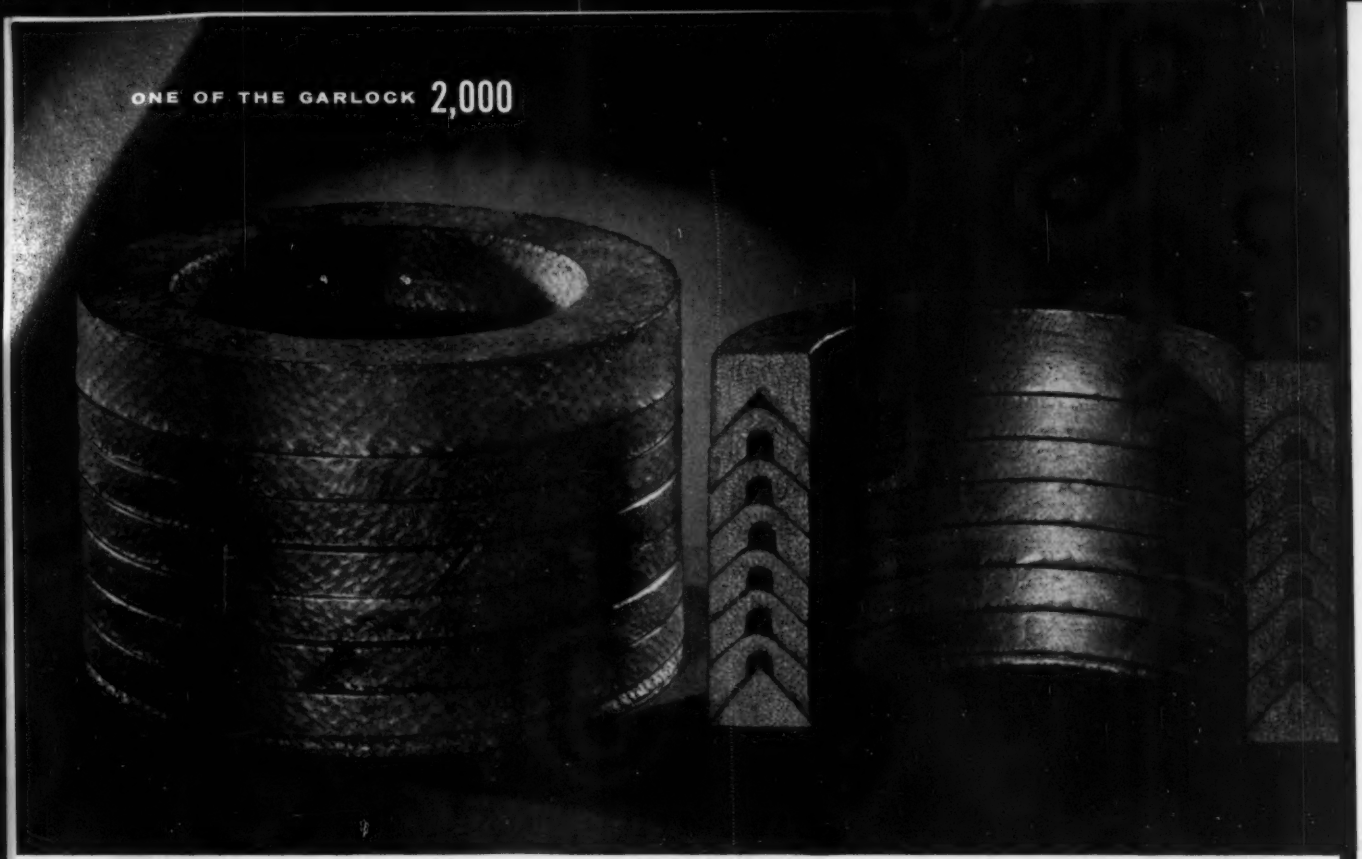
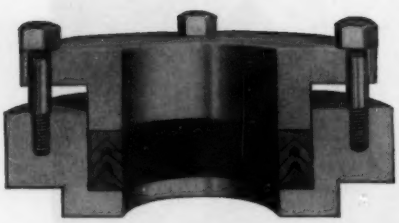


Why Garlock CHEVRON* Packing is really Automatic



This design is entirely different from ordinary V-type packings. CHEVRON has an exclusive hinge-like construction, assuring the automatic action for which it is designed. This also permits the use of less packing in shallower stuffing boxes.

The unique construction of Garlock CHEVRON permits free operation of rods or plungers at all pressures. As pressures increase the packing automatically tightens to prevent leakages. As pressures decline the CHEVRON Rings instantly ease off permitting free operation without leakage.

Therefore, after you make initial adjustment of the gland, no further adjustments are needed to compensate for variations in pressures.

Exclusive CHEVRON is one more part of "the famous Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need—the only complete line. That is why you get *unbiased* recommendations from your Garlock representative. Call him today or write for CHEVRON Folder AD-115.

*Registered trade-mark

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

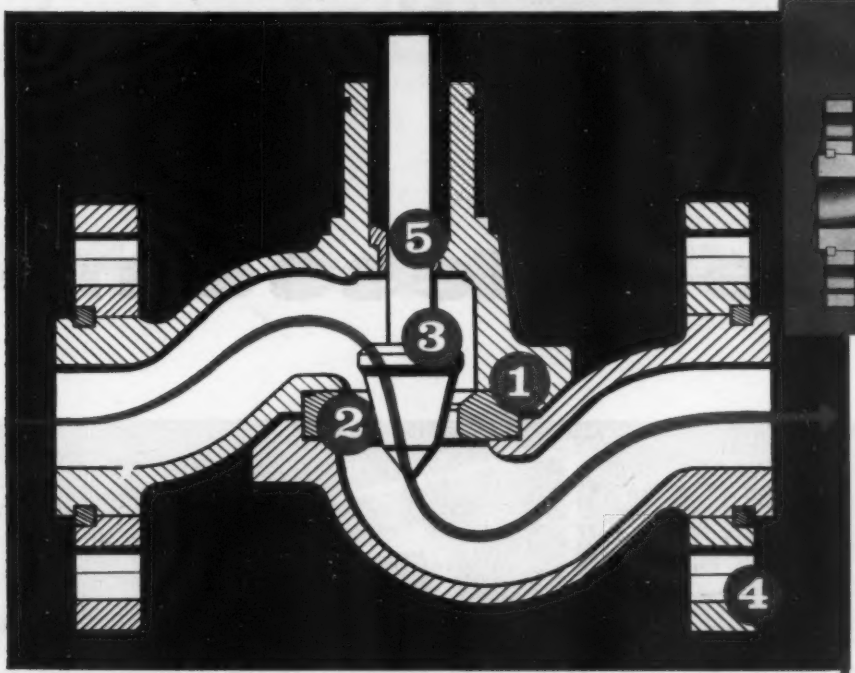
GARLOCK

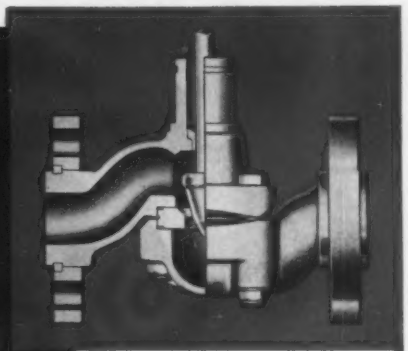
Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

ANNIN BODY DESIGN

...THE SOUNDEST APPROACH TO TROUBLE-FREE FLUID CONTROL

Reduces body turbulence and erosion • Longer seat ring life—retains tight closure • High lift in all sizes for better control—greater rangeability • Fewer parts—simplified and much lower maintenance.

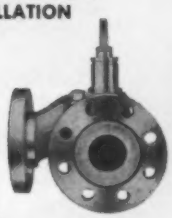


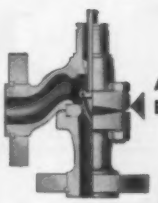


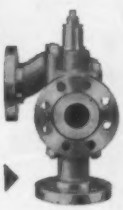
GLOBE BODY ▲

The basic form of all Annin Valves. Reduces number of parts 50 to 75%, lowers initial costs, saves on parts inventory and maintenance.

OTHER BODY DESIGNS PROVIDE FLEXIBILITY IN INSTALLATION







Annin Valves are the answer to the complex fluid control problems common in the process industries—Chemical, Petroleum, Paper, Steam, Power Plants, and many others. Today, Annin Valves are recognized by control engineers and valve designers as the outstanding valve development of the past twenty-five years for the control of hot, cold, erosive, or viscous liquids.

1 BODY. Single seat split body construction eliminates pockets and shoulders... reduces erosion.

2 SEAT RING. The body flanges retain seat in perfect alignment with valve plug.

3 VALVE PLUG AND STEM. Valve plugs are contoured to provide either linear, percentage, or semi-throttle characteristics... reduce turbulence, wire drawing, plug vibration and noise.

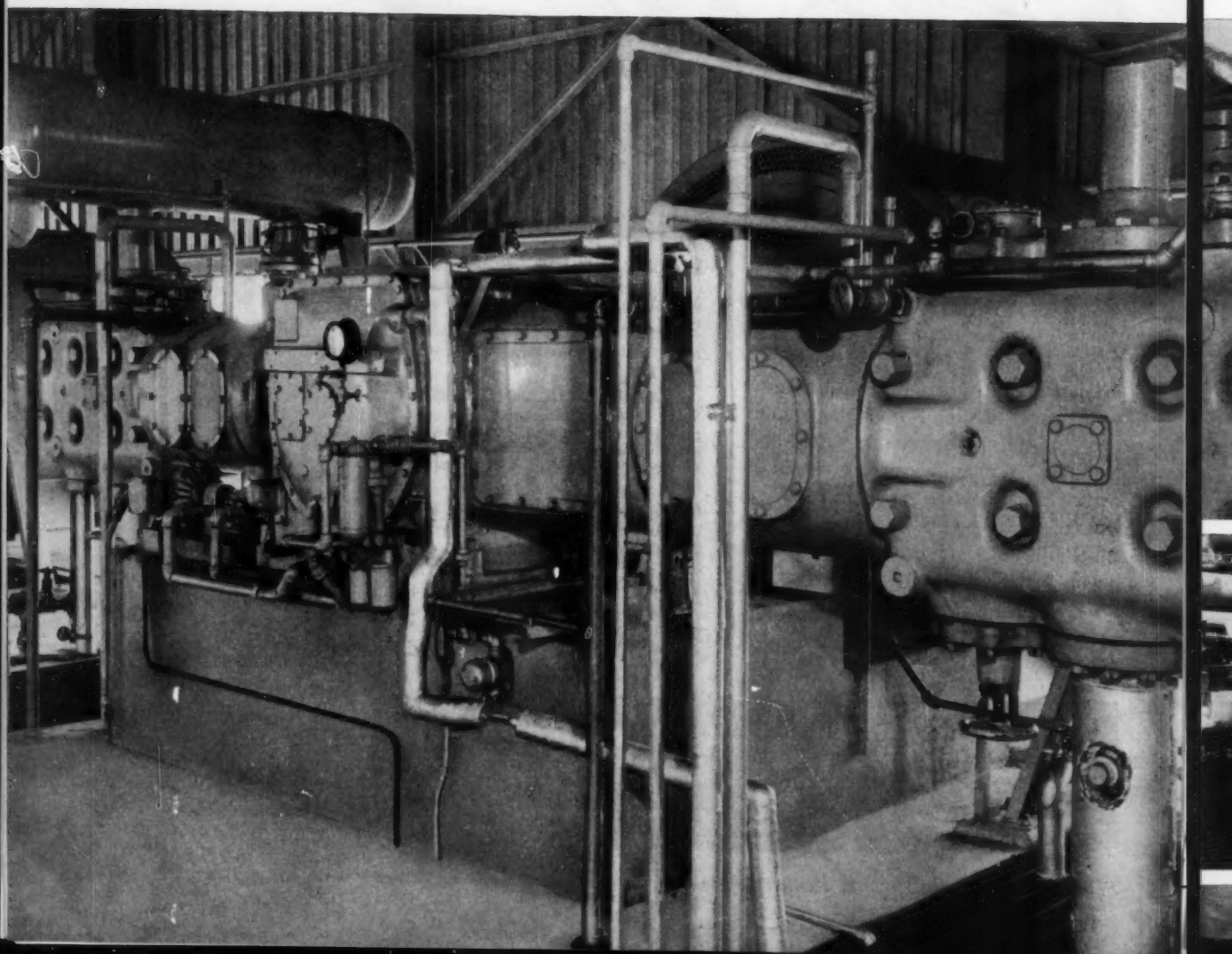
4 SEPARABLE FLANGES. Can be interchanged at will. Carbon steel flanges can be mounted on alloy bodies for economy.

5 PLUG GUIDE. Hard metal guides of close tolerances can be inserted through stuffing box without resorting to threads, welding, pressing or staking.

ANNIN THE ANNIN COMPANY
6570 EAST TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA
Control VALVES

For more data on advertised products, use Readers' Service Cards, last page.

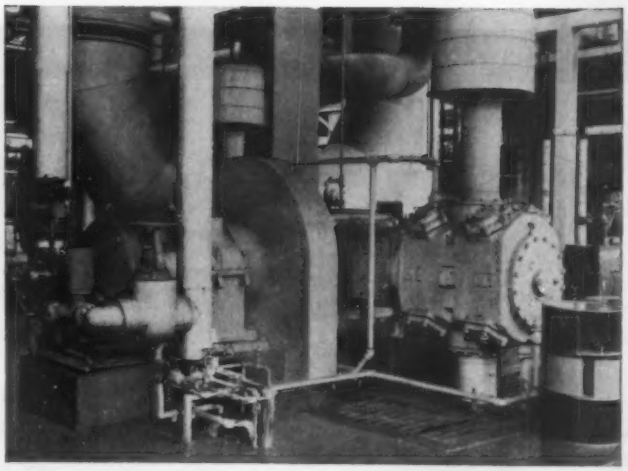
Cooper-Bessemer



1. This 2-cylinder FM compressor, steam turbine driven, supplies aeriation air for this new Tidewater installation.

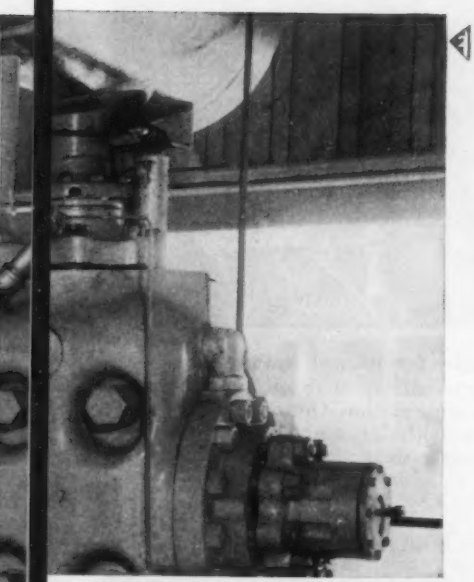
2. To maintain absolute purity in hydrogen compression, this compact motor-driven FM is equipped with non-lubricated cylinders.

3. Handling industrial air requirements for Tidewater's Delaware refinery . . . three 4-cylinder Cooper-Bessemer compressors,—one synchronous driven and two steam turbine driven.



1

r FM Compressors



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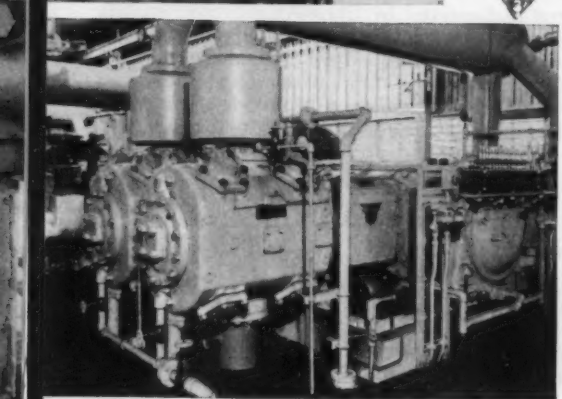


3

...for simplicity and efficiency in meeting multiple requirements ***in the world's largest refinery ever to be built at one time***

BRANCH OFFICES: Grove City • New York • Chicago • Washington • San Francisco • Los Angeles • Houston • Dallas • Odessa • Minneapolis • New Orleans • Shreveport • Casper

SUBSIDIARIES: Cooper-Bessemer of Canada, Limited . . . Edmonton • Calgary • Halifax
Cooper-Bessemer International Corporation . . . New York
Caracas • Havana • Mexico City

Cooper Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

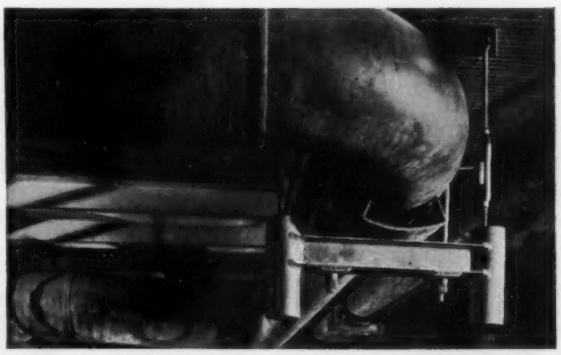
ENGINES: GAS - DIESEL - GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE OR MOTOR DRIVEN

BLAW-KNOX has what it takes—to provide these products and services

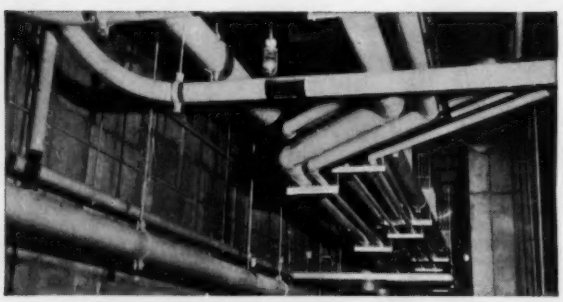
A Blaw-Knox automatic sprinkler system could have prevented this disastrous fire. Each year a serious fire strikes one out of seven manufacturing firms in this country. And out of every 100 firms who lose their records in a fire, 43 never reopen for business. So why take any chances.

Blaw-Knox engineers, fabricates and installs automatic sprinkler systems that are always alert to detect, confine and quench a fire at its origin. Qualified engineers custom-design systems that meet individual requirements—and fulfill all insurance standards and municipal codes. A Blaw-Knox automatic sprinkler system pays for itself in a few years through savings in reduced insurance premiums.

Let a Blaw-Knox fire-protection engineer study your needs, submit a layout and estimate, and tell you how you can pay for the system on our lease or deferred payment plan. For more complete information, write for Bulletin No. 2426—"Fire Can Destroy Your Business."



Blaw-Knox trapeze functional spring hangers, with the patented internal swivel action, support power piping in new generating station. Our experienced engineers are available to both design and make recommendations for your hanger requirements. For further information, send for Catalog No. 54.



High temperature, high pressure oil tunnel piping in large steel mill is typical of many piping systems prefabricated and erected by Blaw-Knox. Experienced piping engineers, modern shop facilities and a new Blaw-Knox digital computer method for fast, accurate calculation of piping stresses are available to you. Let us know your requirements and we will provide the service you need. For additional information, write for Bulletin No. 2443—"Piping for Industry."

BLAW-KNOX

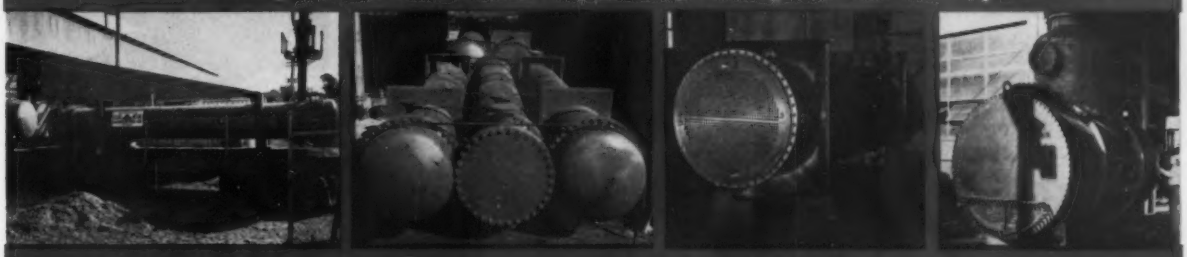
BLAW-KNOX COMPANY

Power Piping and Sprinkler Division

829 Beaver Avenue • Pittsburgh 33, Pennsylvania

Complete facilities for prefabrication and erection of piping systems for all pressures and temperatures ... complete line of standard and custom-engineered pipe hangers, supports and vibration eliminators ... complete line of automatic sprinkler systems for standard and special hazards

Exchangers like these serve dependably throughout the industry.



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PETRO-CHEMICAL INDUSTRY

in Custom-Design, Fabrication and Repair of

HEAT EXCHANGERS

Qualified for Construction in Ferrous and Non-Ferrous Materials

MTF

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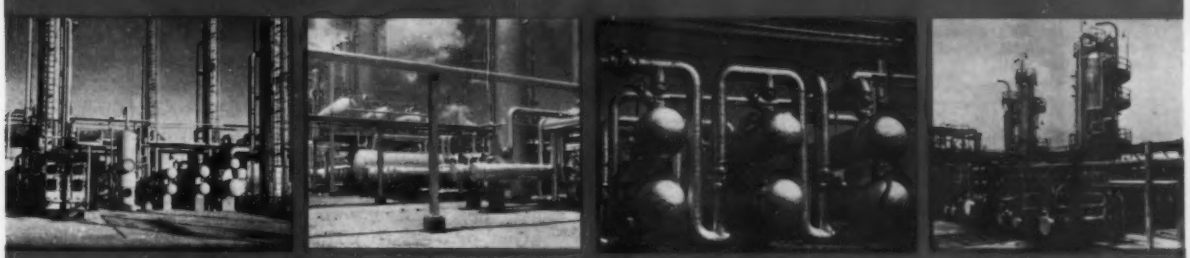
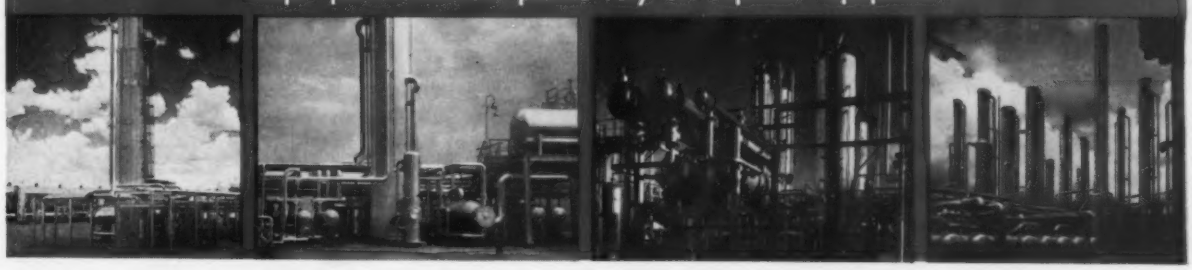
Your inquiries are cordially invited.

TEXAS METAL FABRICATING COMPANY

P. O. Box 7567, Houston 7, Texas



Major petro-chemical plants rely on superior equipment.



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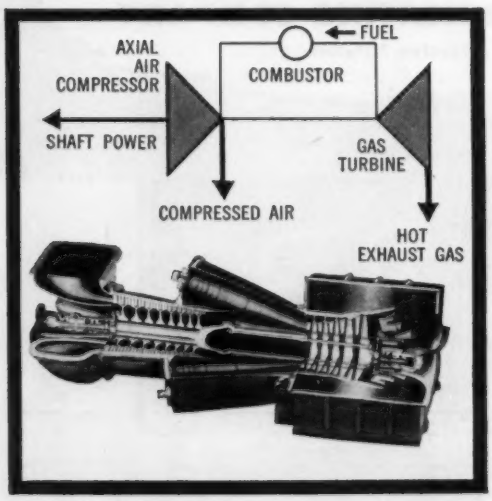
3 FROM 1

Shaft power, compressed air, heat... all from one gas turbine...

BY TAKING ADVANTAGE of the versatile Westinghouse gas turbine, engineers are simplifying many processes. For example . . .

As gasifiers—In a large Southwestern butadiene plant, four Westinghouse gas turbines will soon be operating as gasifiers for the reactivation of the catalyst and each will eliminate the need for a separate prime mover and a separate air compressor.



In addition, smaller line heaters and less fuel will be used because *all* the *Btu's* put into the gas turbine are exhausted to the heaters and process, with the exception of minor radiation and bearing losses.

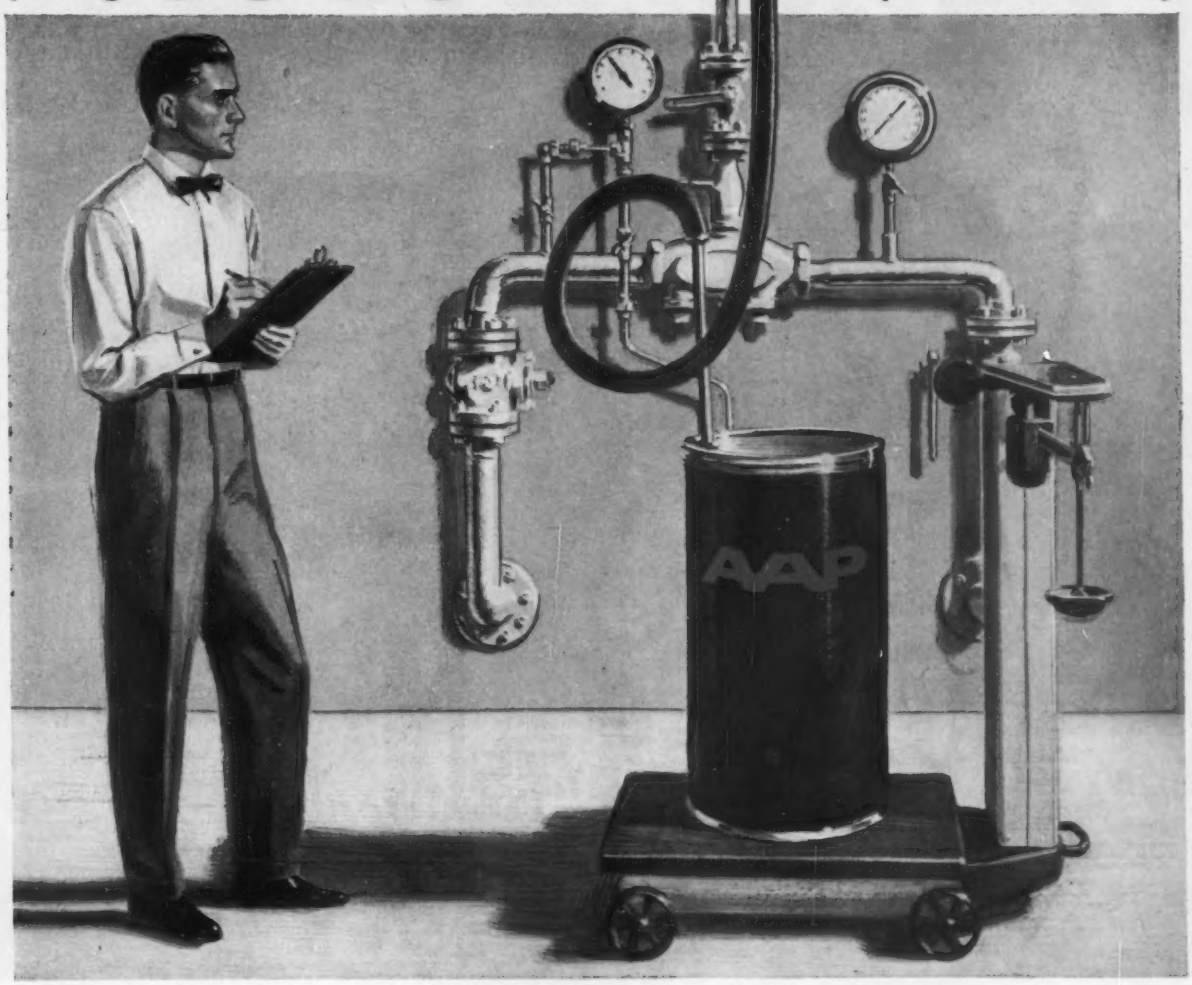
Versatility—The modern Westinghouse gas turbine can be used to streamline processes, for it offers many combinations of output:

Shaft power.....up to 22,500 hp
Compressed air.....up to 85 psia
Hot gas (18% oxygen) .....up to 1000°F

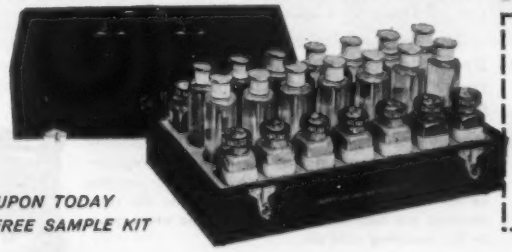
Ask today for your set of suggested process sketches. Contact your Westinghouse representative, or write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-50598

YOU CAN BE SURE...IF IT'S Westinghouse

putting COLOR to work for the petroleum industry



More and more petroleum refiners are turning to American Aniline for experienced help in utilizing oil colors to simplify identification and impart added sales appeal to motor oils, greases and gasolines. A.A.P. Oil Colors are nationally known for their constancy of shade and strength. Each may be employed in a variety of ways including the popular **eductor system.** All A.A.P. dye drumheads are equipped with a plastic opening to accommodate the dry-dye eduction tube. Colored plastic plugs representing the color of the dye in each drum are furnished with each shipment. A sales engineer from our nearest branch is ready to furnish details on the full range of shades available.



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AAP

AMERICAN ANILINE PRODUCTS

A UNIT OF KOPPERS CO., INC.

KOPPERS BUILDING, PITTSBURGH 19, PA. PLANT: LOCK HAVEN, PA.
BRANCHES: Providence, R. I. • Philadelphia, Pa. • Paterson, N. J. • Chicago Ill. • Charlotte, N. C. • Chattanooga, Tenn. • Columbus, Ga. • Los Angeles, Cal.
Dominion Anilines & Chemicals, Ltd., Toronto, Canada • Montreal, Canada

Please send FREE your laboratory evaluation kit as illustrated of A.A.P. Oil Colors to:

NAME.....

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Mail to our Pittsburgh office or nearest branch. Our local representative will be happy to offer full information and technical advice at any time.

—Photograph courtesy of Standard Oil Company (N. J.)

How much can preheat raise throughput?

Today's soaring production costs spotlight the need for increasing throughput . . . that is, if slim profit margins are to be kept from disappearing altogether. A look at the Ljungstrom Air Preheater will show how this can be done.

Ljungstrom efficiency comes from the fact that preheated air mixes more thoroughly with fuel. This assures more complete combustion . . . higher flame temperature . . . and increased heat absorption into the tubes – which raises still throughput by as much as 25%!

For example, an eastern refinery went from 16,000 barrels to 18/20,000 barrels a day when the pipe still was modernized with a Ljungstrom system. In addition, temperature control was much closer. The octane rating of the product, because of this fine control, was held to narrower limits – *with the average rating as much as two octane numbers higher.*

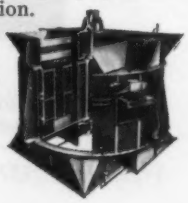
How fast is "WRITE OFF"?

In earnings from increased output and improved quality, many refineries write off the cost of the Ljungstrom in less than 2 years. These costs can be written off sooner, in fact, when you add other Ljungstrom advantages: savings up to 20% in fuel costs . . . higher throughput . . . less slag . . . and use of fuels you used to discard.

For more complete data on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits obtainable in fuel burning equipment – call or write the Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.



The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

Fabricators of:

PRODUCTS

Absorbers

Bubble Towers

Bubble Caps

Bubble Trays

Dephlegmators

Evaporators

Fractionating Columns

Jacket Water Coolers

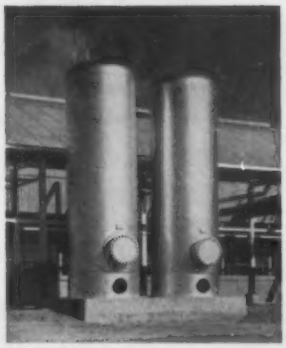
Heat Exchangers

Stabilizers

Pressure Vessels

GASOLINE PLANT, OIL REFINERY and CHEMICAL PROCESSING EQUIPMENT

For over forty years FLINT **has been** one of the largest and best equipped fabricators of **Process Equipment** for the Petroleum & Chemical Industries.

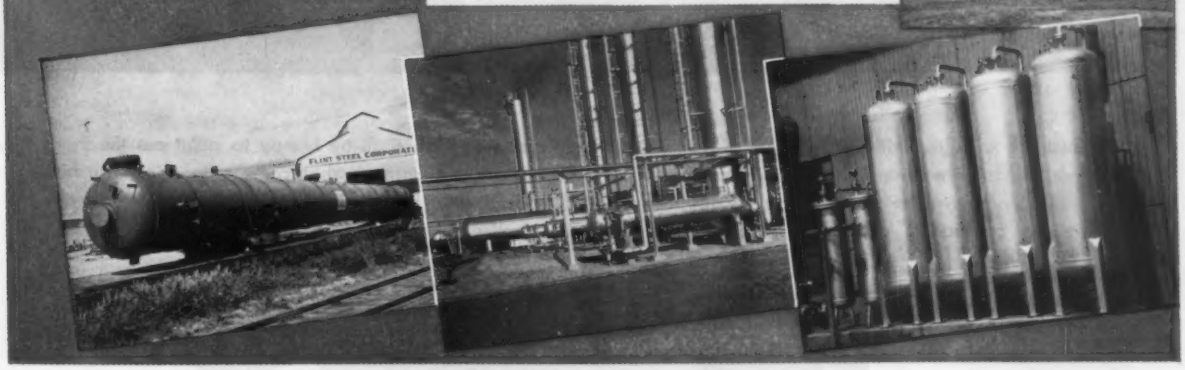


Roll capacity is 1¾" or 2" thick plate. Flint also has Radiograph and stress relieving equipment.

API-ASME or the ASME CODE for Unfired Pressure Vessels is complied with readily.

Stress relieving furnace is 15′ 2" wide by 85′ long.

The manufacturing facilities of the two Plate Shops with their machinery and equipment make Flint one of the largest fabricators of steel plate products for the Processing Industries in the country.



STEEL PLATE FABRICATORS ASSOCIATION

FLINT STEEL CORPORATION

TULSA ..... MEMPHIS

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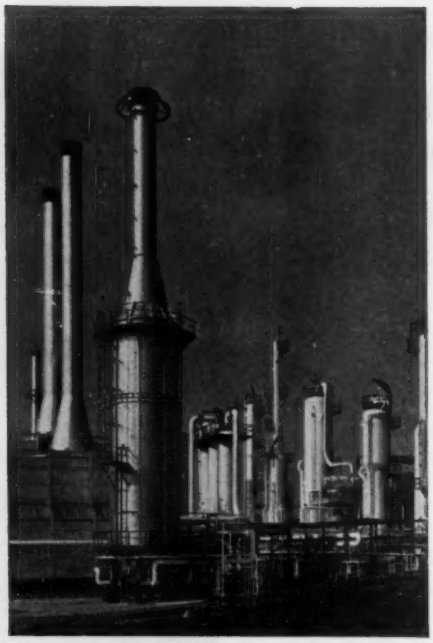


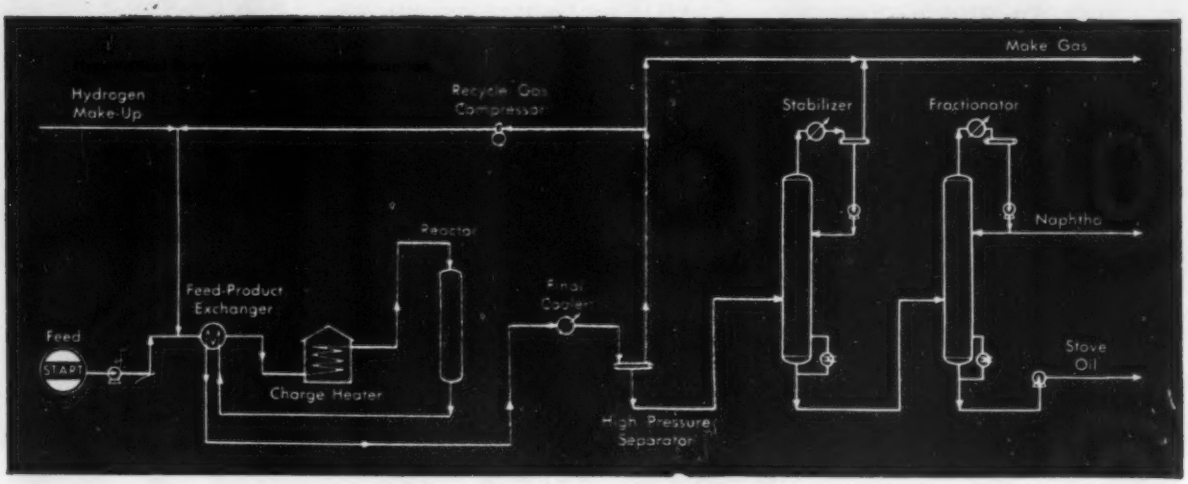
Unifining Unit, Union Oil Company of California refinery, Oleum, California uses Harshaw Cobalt Molybdate Catalyst.

For Hydrodesulfurization

HARSHAW COBALT MOLYBDATE CATALYST

★ **223 regeneration cycles without loss in activity**—a typical performance given by Harshaw Cobalt Molybdate Catalyst, accomplished while treating one of the most difficult charge stocks.

★ **Recording less than 1.0¢/bbl. accumulated costs**—with no indicated loss of activity, Harshaw CO-MO has been full scale tested the longest of any hydrodesulfurization catalyst.



Since you know the critical ingredient of any catalytic hydrogenation reaction is the *catalyst*, the above facts should prompt you to acquire complete details on this premium commodity in the field of catalytic hydrogenation. We shall be happy to point out the many specific advantages that come with using Harshaw Cobalt Molybdate Catalyst and discuss any specific application you may be considering.

Feel free to contact your nearest Harshaw office

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THE HARSHAW CHEMICAL CO.

1945 E. 97th Street · Cleveland 6, Ohio

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Cincinnati
Cleveland
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Hastings-On-Hudson, New York
Houston
Los Angeles
Philadelphia
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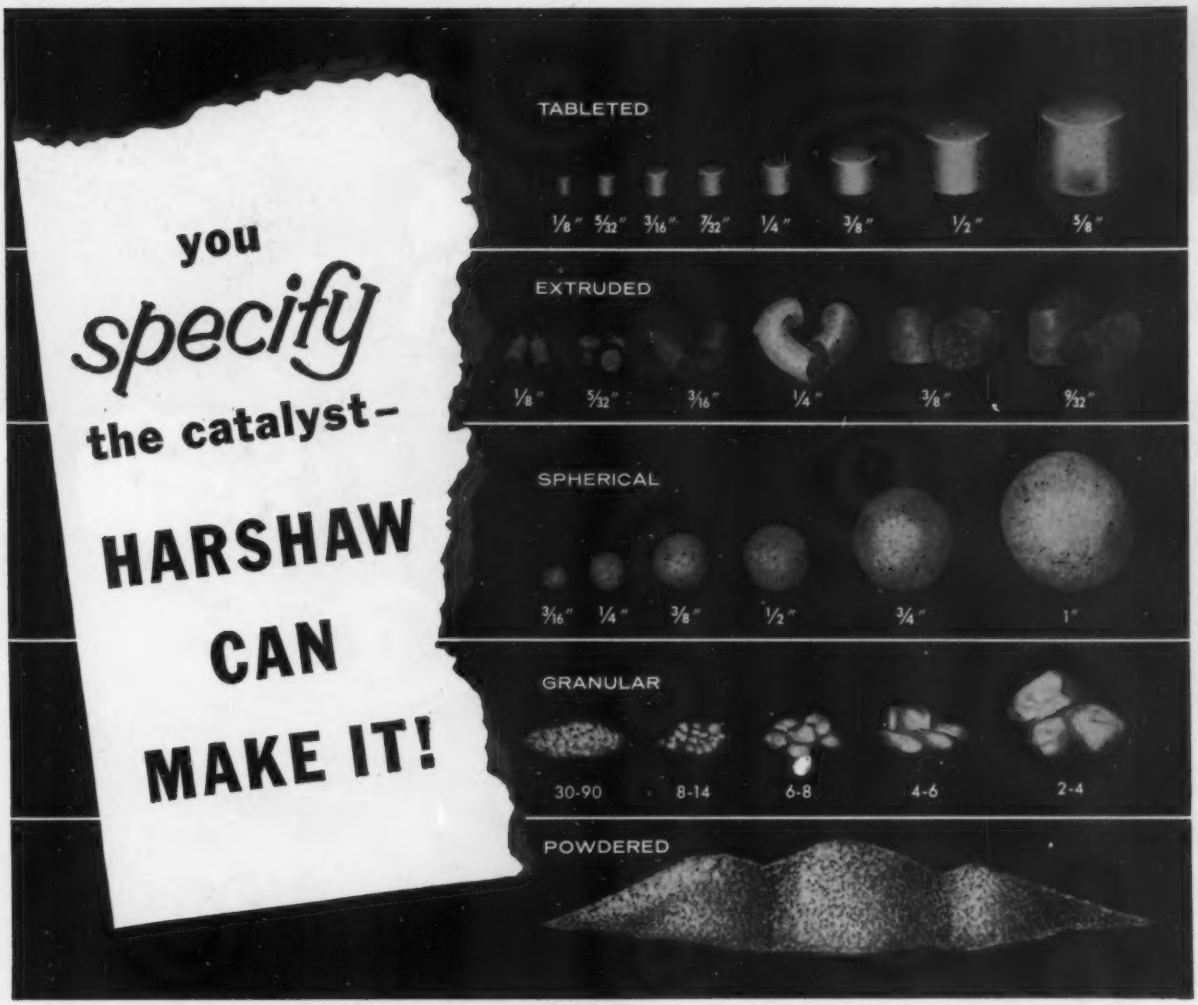

HARSHAW

has the facilities for producing carload quantities of

PREFORMED CATALYSTS

to fit special process requirements

Hydroforming — Dehydration
Cyclization — Desulphurization
Oxidation — Alkylation
Dehydrogenation — Isomerization
Hydrogenation

CATALYTIC CHEMICALS SUPPLIED BY HARSHAW

Aluminum Nitrate — Cobalt Nitrate
Copper Nitrate — Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)
Nickel Carbonate — Nickel Formate — Nickel Nitrate
Nickel Sulfate — Sodium Methoxide — Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

Write for FREE Booklet, "HARSHAW CATALYSTS"

HARSHAW

THE HARSHAW CHEMICAL CO.

1945 EAST 97th STREET • CLEVELAND 6, OHIO

Chicago • Cincinnati • Cleveland • Hastings-On-Hudson, N.Y. • Houston • Los Angeles
Detroit • Philadelphia • Pittsburgh

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Anaconda Type CP Cable being buried on cathodic protection job. Special covering resists almost every soil condition you're likely to meet.

Special cathodic protection cable gives you longer cable life even in "problem soils"

Soils vary. One may be acidic. The next alkaline. One dry. Another wet.

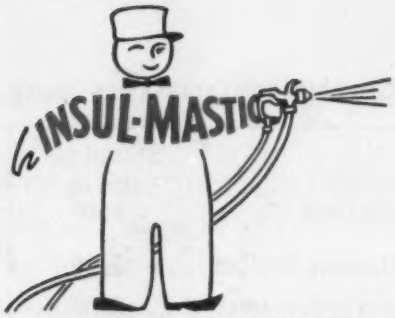
Now Anaconda offers you a special Type CP cable that gives you the very best performance under all these conditions—under *any* condition you're likely to meet.

This cable is *especially* designed for cathodic protection. Its plastic covering resists electro-endosmosis, oil, moisture, and most acids, alkalies and chemicals found in corrosive soil areas. It's rugged, too. Resists abrasion and weathering.

Its greater dependability means fewer repairs . . . lower operating costs.

For full information, call the Man from Anaconda. Or write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y. 57388

ASK THE MAN FROM **ANACONDA®**
ABOUT **TYPE CP CABLE**



A New Member of the PITT CHEM Protective Coatings Family!

FAMOUS *Insul-Mastic* "Gilsonite" coatings have joined the *Pitt Chem* family of industrial protective coatings! Thus, Pittsburgh Coke & Chemical Company—through the recent acquisition of Insul-Mastic Corporation of America—now offers you the *most complete line of bituminous protective coatings on the market.* That means that you can now obtain, from one dependable, experienced source, high quality bituminous coatings specifically formulated to effectively and economically combat virtually any corrosion problem you may encounter. Now, more than ever, *Pitt Chem* is the name to remember when you want reliable corrosion protection—for *Pitt Chem* now means *Insul-Mastic,* too! Call for a *Pitt Chem* technical representative to survey *your* specific corrosion problem. A call, letter or wire will place him at your service.

PITT CHEM
Coal Tar Pipeline Enamels

Time-tested hot-applied pipeline enamels, manufactured to rigid, published specifications. Used by scores of leading pipeline companies for long-lasting protection of major underground gas and petroleum product lines.

PITT CHEM
Insul-Mastic Coatings

A performance-proven family of vapor sealing and insulating asphalt coatings containing a high percentage of Gilsonite. These thick mastic coatings serve excellently as moisture and vapor barriers on insulation and other surfaces exposed to the elements above ground.

PITT CHEM
Coal Tar Coatings

A broad family of cold applied coal tar coatings that provide excellent corrosion protection on metal, masonry, concrete or stone. Includes "*Tarset,*" the revolutionary coal tar-epoxy resin coating.

COAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON

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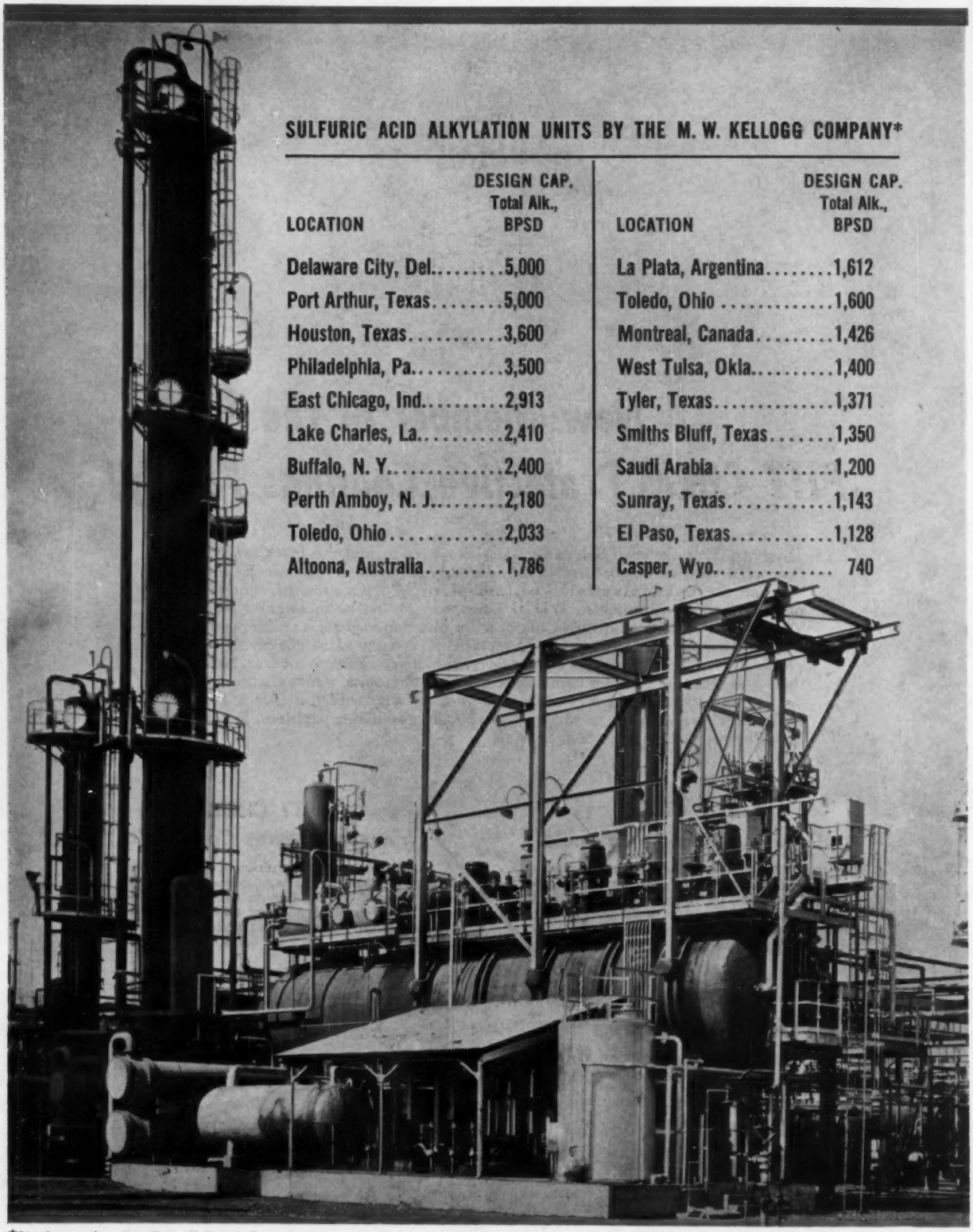
Today's Ultimate



SULFURIC ACID ALKYLATION UNITS BY THE M. W. KELLOGG COMPANY*

LOCATION	DESIGN CAP. Total Alk., BPSD	LOCATION	DESIGN CAP. Total Alk., BPSD
Delaware City, Del.	5,000	La Plata, Argentina	1,612
Port Arthur, Texas	5,000	Toledo, Ohio	1,600
Houston, Texas	3,600	Montreal, Canada	1,426
Philadelphia, Pa.	3,500	West Tulsa, Okla.	1,400
East Chicago, Ind.	2,913	Tyler, Texas	1,371
Lake Charles, La.	2,410	Smiths Bluff, Texas	1,350
Buffalo, N. Y.	2,400	Saudi Arabia	1,200
Perth Amboy, N. J.	2,180	Sunray, Texas	1,143
Toledo, Ohio	2,033	El Paso, Texas	1,128
Altoona, Australia	1,786	Casper, Wyo.	740

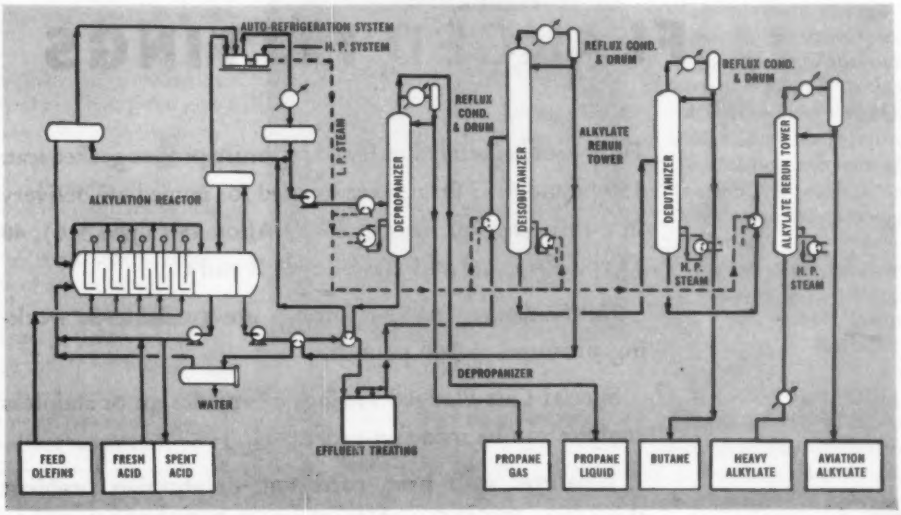
*List shows only units utilizing Kellogg's Cascade Reactor. Kellogg has also engineered and built many alkylation units of other types.

in ALKYLATE . . .

Measured by every standard . . . by quality and quantity of yield . . . by initial investment . . . by operating costs . . . M. W. Kellogg's sulfuric acid alkylation process is bringing optimum results to an increasing number of leading refiners both at home and abroad.

With its present advanced design, utilizing the company's unique multiple-stage cascade reactor and auto-refrigeration system, Kellogg alkylation offers the ultimate today in high isobutane efficiency, low acid consumption, low outlay for recycle and auxiliary equipment, and low utilities cost.

The M. W. Kellogg Company welcomes the opportunity to describe this alkylation process in detail, and to acquaint refiners with the improvements its engineers are continually making toward still greater economy and efficiency.



Refinery Process Division

The M. W. Kellogg Company

711 Third Avenue, New York 17, N.Y.

A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Company Ltd., Toronto • Kellogg International Corp., London • Kellogg Pan American Corp., New York • Societe Kellogg, Paris • Companhia Kellogg Brasileira, Rio de Janeiro • Compania Kellogg de Venezuela, Caracas

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BUTT IT... **BOLT IT...AND BEAT CORROSION**

WITH ESCO CAST FLANGED FITTINGS

Faces are accurately machined to insure proper gasket seat. 150-pound MSS fittings are stocked for immediate delivery in a full range of sizes in *ESCO* Alloy 45 (Type 316), 40 (Type 304), 20* and Hastelloy** B and C.

Heavy flanged (ASA) Fittings are available in working pressures to 900 pounds.

Special Cast Flanged Fittings of any design or stainless analyses can be made on order.

Whatever your heat, corrosion, or abrasion problem there is an *ESCO* Cast Alloy that's *right* for the job.

*Duriron Licensee **Haynes-Stellite Licensee

See your ESCO Dealer. Ask for Catalog No. 175.

ESCO®

ELECTRIC STEEL FOUNDRY COMPANY
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MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.
Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

IS A METAL DEACTIVATOR WORTH WHILE?

TENAMENE 60 pays off in case after case

Eastman Copper Chelating Additive

- **Inhibits gum formation in motor gasoline**
- **Stops color degradation in kerosene**
- **Reduces fuel oil clogging**
- **Improves stability of jet fuel**

Even trace amounts of copper can be extremely harmful to most petroleum products.

Eastman's metal deactivator, Tenamene 60, used in amounts from 1 to 3 pounds per 1,000 barrels, protects most petroleum products in storage and during use from the detrimental effects of copper-catalyzed oxidation reactions. A chelating agent, Tenamene 60 ties up the copper to form a non-reactive, non-catalytic compound.

Gasoline

Copper has a powerful pro-oxidant effect on gasoline and catalyzes normal gum-forming reactions. Its presence requires an excessive amount of antioxidant to obtain a satisfactory induction period. A more effective and a more economical method is to use Tenamene 60 in conjunction with a normal amount of antioxidant.

Refiners need Tenamene 60 for adequate protection of motor gasoline. The increased use of catalytically cracked stocks makes storage a particularly troublesome problem inasmuch as these stocks are more susceptible to oxidation and, hence, to the catalytic action of copper. The test data shown in the accompanying table below demonstrate the beneficial results obtained from the use of Tenamene 60 in a blended gasoline containing approximately 45% catalytically and thermally cracked stocks.

Effectiveness of Tenamene 60 in Protecting Gasoline

Sample	Induction Period	Peroxide Number	ASTM Gum	Copper Dish Gum
Unprotected Gasoline				
Initial	330	0.1	3.1	4.0
After 20 weeks at 110°F	—	30+	116+	575+
Gasoline protected with Tenamene 60*				
Initial	780	0.1	3.1	4.0
After 20 weeks at 110°F	—	1.0	4.6	8.0

*2 lbs. per 1,000 bbls.

Alchemist's symbol for copper

Kerosene

When kerosene is copper-sweetened or contains dissolved copper from other sources, color degradation frequently occurs due to the catalytic action of the copper. The Saybolt color value of a typical untreated kerosene containing copper, heated for 24 hours at 212°F, changed from 25 to 14. Protected by just 2 pounds of Tenamene 60/1,000 barrels, the Saybolt color value of this same kerosene changed hardly at all...from 25 to 24.

Diesel and Home Heating Fuel

Two problems exist in the storage and use of diesel and home heating fuels. One is formation of copper-mercaptide, a waxy, jelly-like substance, on brass screens, nozzles and filters. The second is formation of an organic gum-like material that binds sludge. Tenamene 60 helps solve both problems by retarding the catalytic action of copper promoting these reactions.

Jet Fuels

Test results using a CFR fuel Coker* instrument show the addition of a small amount of Tenamene 60 increases significantly the stability of most jet fuels at high temperatures when these fuels contain copper. Tenamene 60 is approved and widely accepted for use in this type of fuel.

Tenamene 60 also should be evaluated as a means to improve the stability and performance of *turbine oils, bearing greases, hydraulic fluids* and *lubricants* subject to copper-catalyzed oxidation.

In case after case, use of Tenamene 60 insures optimum performance of gasoline, fuel oil, kerosene, jet fuels ...especially following prolonged storage.

Investigate the protection Tenamene 60 can bring your refinery products. For more information, write to EASTMAN CHEMICAL PRODUCTS, INC., a subsidiary of EASTMAN KODAK COMPANY, Kingsport, Tennessee.

*The CFR fuel Coker instrument (ERDCO rig) measures the rate at which pressure develops as heated fuel is circulated through a filter. Test results are relative and are given as "fuel goodness ratings."

Tenamene 60
EASTMAN METAL DEACTIVATOR

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; New York City; Framingham, Mass.; Cincinnati; Cleveland; Chicago; St. Louis; Houston. **West Coast: Wilson Meyer Co.,** San Francisco; Los Angeles; Portland; Salt Lake City; Seattle; Denver; Spokane; Phoenix.

For more data on advertised products, use Readers' Service Cards, last page.

For catalytic reforming...

Forty refineries specified Clark

User	*Location*	*No. of Units*
Atlantic Refining Company, The	Point Breeze, Pennsylvania	2
BP Refinery (Kent) Ltd.	Kent, England	1
Burmah-Shell Refineries Ltd.	Bombay, India	1
Bahrain Petroleum Company, Ltd., The	Bahrain, Persian Gulf	1
Caltex Petroleum Maatschappij N.V.	Pernis, Holland	1
Compagnie Francaise de Raffinage	La Mede, France	1
Gulf Oil Corporation	Girard Pt., Pennsylvania	4
Gulf Oil Corporation	W. Pt. Arthur, Texas	4
*	Eastern Canada	1
McColl-Frontenac Oil Company Limited	Montreal, Canada	1
Ohio Oil Co., The	Robinson, Illinois	1
Phillips Petroleum Company	Phillips, Texas	1
Phillips Petroleum Company	Kansas City, Kansas	1
Pure Oil Company, The	Smith Bluff, Texas	1
Refineria de Petroleos de Escombreras, S.A.	Cartagena, Spain	2
Shell Oil Company	Wood River, Illinois	2
Shell Oil Company	Deer Park, Texas	1
Shell Oil Company	Houston, Texas	2
Shell Oil Company	Anacortes, Washington	1
Shell Oil Company of Canada Limited	Montreal, Canada	1
Shell (Refining) Australia Pty. Ltd.	Geelong, Australia	1
Sinclair Refining Company	Marcus Hook, Pennsylvania	2
Sinclair Refining Company	E. Chicago, Illinois	2
Societe Francaise des Petroles BP	Dunkirk, France	1
Societe Industrielle Belge des Petroles	Antwerp, Belgium	1
Socony Mobil Oil Company, Inc.	Paulsboro, New Jersey	1
Societe per l'Industria Italiana del Petrolio	La Spezia, Italy	1
Standard Oil Co. of California	El Segundo, California	2
Standard Oil Co. of California	Richmond, California	2
*	Central Kansas	1
Standard Oil Co. of Ohio	Toledo, Ohio	2
Sun Oil Company	Toledo, Ohio	1
D-X Sunray Oil Company	Tulsa, Oklahoma	1
Suntide Refining Company	Corpus Christie, Texas	2
Texas Company, The	Wilmington, California	1
Texas Company, The	Laurenceville, Illinois	2
Texas Company, The	Westville, New Jersey	2
Texas Company, The	Pt. Arthur, Texas	5
Tidewater Oil Company	Delaware City, Delaware	1
Wilshire Oil Co. of California	Norwalk, California	2

*Name furnished on request

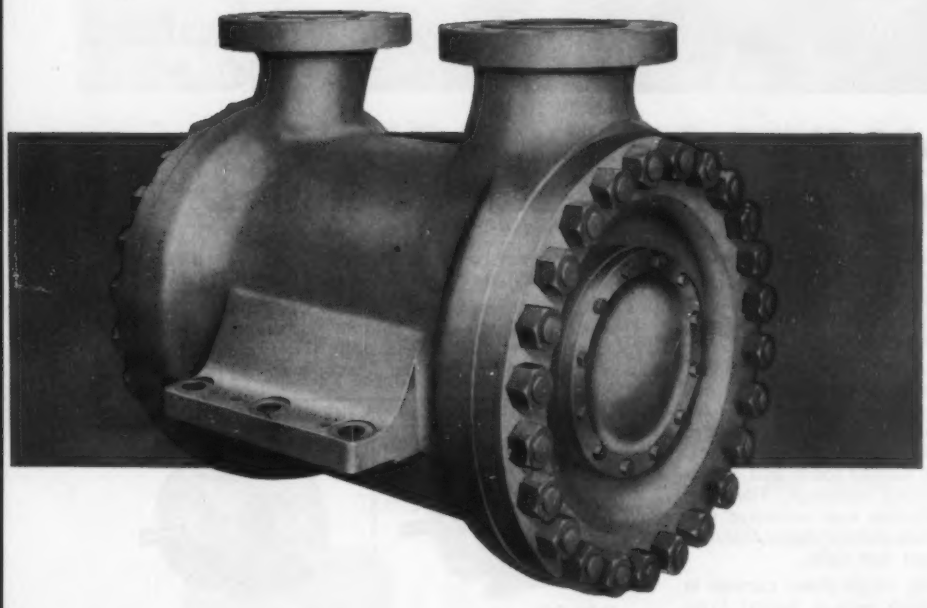
60% choose Clark

Vertically-split centrifugal compressors

Forty major refineries are using or have ordered Clark vertically-split centrifugal compressors for their reforming needs. That's over 60% of the total requiring centrifugal compressors.

We could mention many reasons why these Clark units outsell all other makes combined, but we prefer to let the facts speak for us. Remember 6 out of 10 are Clark . . . how about your next reformer?

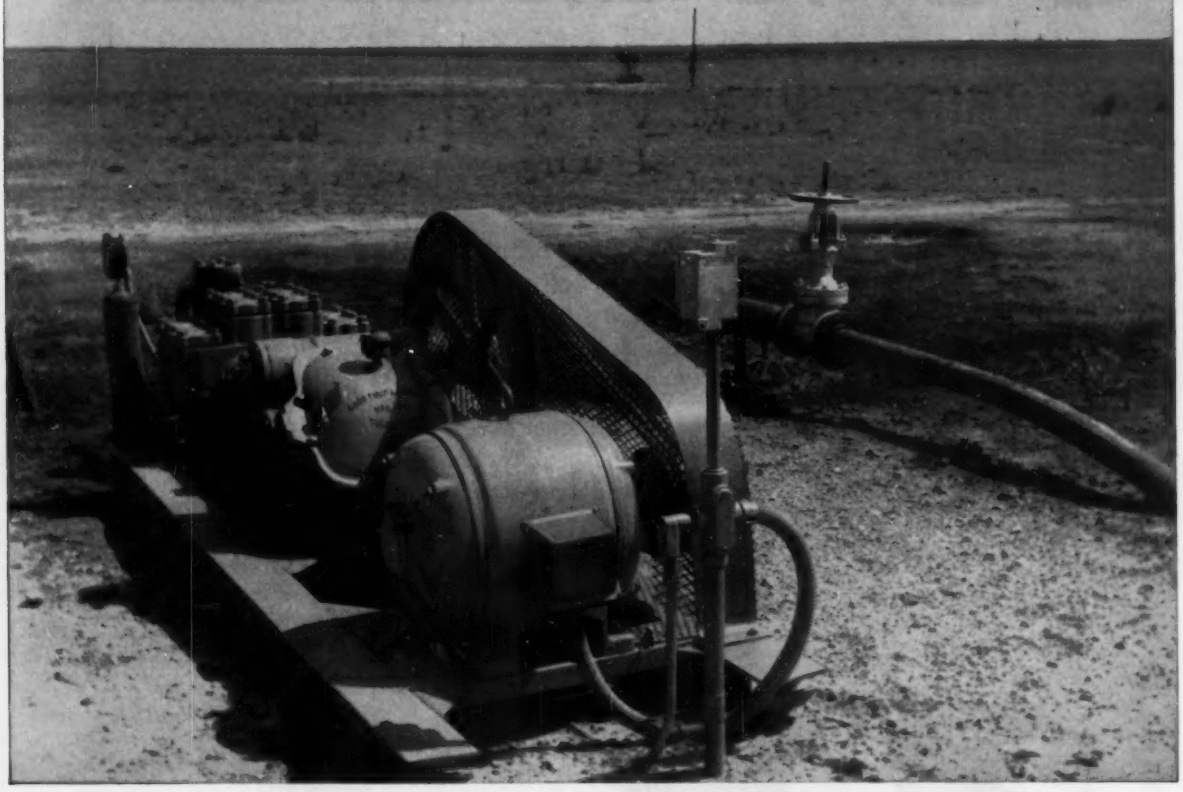
CLARK BROS. CO., OLEAN, N. Y.
One of the Dresser Industries
Offices in Principal Cities throughout the World



CLARK® Centrifugal Compressors

For more data on advertised products, use Readers' Service Cards, last page.

WAGNER ELECTRIC MOTORS . . . THE CHOICE OF LEADERS IN INDUSTRY



for uninterrupted gathering . . . power your pumps with Wagner Motors

A motor that drives a pipe line gathering pump has a downright lonesome job. Nothing for company but an occasional horned toad or rattlesnake. Even the visits of the maintenance crew are few and far between—especially if it's a Wagner Motor.

Wagner Type DP cast-iron frame oil well pumping motors are especially designed for year around, maintenance-free, rugged outdoor service. They are protected against rain, sand, snow, by an enclosure that is completely drip-proof—virtually splash-proof. They are protected against horned toads and rattlesnakes by screened ventilating openings. They are protected against acids, alkalies and corrosive elements by their cast iron frames and endplates. Conduit boxes are moisture-proof and dust tight.

For locations where only single-phase current is available, Wagner has high power factor type capacitor-start motors with the same protection. You can get Wagner oil well pumping motors *from stock* in your immediate area.

Wagner also supplies the petroleum industry with Type JP explosion-proof motors in ratings through 250 hp. Bulletins MU-132 and MU-137 give full information. Write for your file copies.

TIME-TESTED FAVORITES OF THE PETROLEUM INDUSTRY

TYPE DP

TYPE JP

In the field . . . *In the refinery!*

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

H57-15

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation
6458 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

SHOOT

POUR

TROWEL

ADACAST extra strength refractory

...SPECIALLY FOR PETRO-CHEM APPLICATIONS

... ADACAST Extra Strength is a castable that can be shot, poured or trowelled ... *specially designed* for those applications where high strength and resistance to abrasion and fly ash erosion are of prime importance (where high temperature resistance is not so much a factor). For Oil Stills and Heaters ... BOTFIELD Castables are manufactured in all grades ... from high strength dense to extremely light weight ... with high insulating value ... for *every* purpose in the Refining and Chemical Processing Industries.

Write for the new BOTFIELD Refractory Castables bulletin # 27

Yellow pages of 'phone book have your nearest ADAMANT Distributor.

Botfield

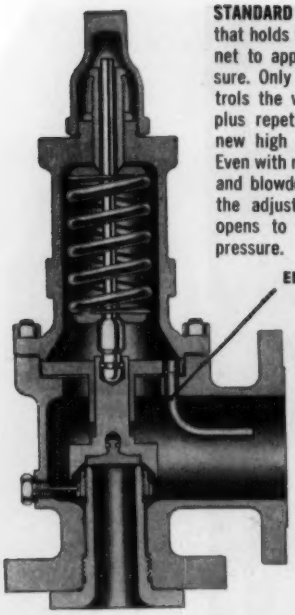
FOUNDED 1907

REFRACTORIES

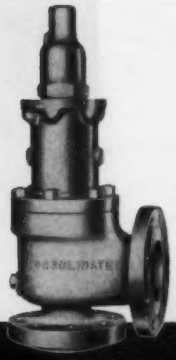
ADAMANT and other ADA products

swanson and clymer sts.
philadelphia 47, penna.

For more data on advertised products, use Readers' Service Cards, last page.

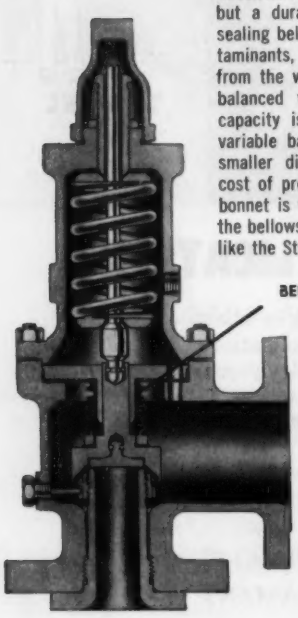


STANDARD VALVE. Note the eductor tube that holds the pressure in the valve bonnet to approximately atmospheric pressure. Only the force of the spring controls the valve. Far better valve action plus repetitive flow capacity assure a new high in operational dependability. Even with repeated popping, set pressure and blowdown are consistent. Whatever the adjusting ring position, the valve opens to full capacity at 10% over-pressure.



LOOK INSIDE

before you buy another safety relief valve



BELLOWS VALVE. Similar to the Standard, but a durable, two-ply stainless steel sealing bellows effectively isolates contaminants, corrosion or viscous fluids from the working parts. The bellows is balanced with the seating surface — capacity is less seriously affected by variable back pressure, so the use of smaller discharge piping reduces the cost of pressure-relieving systems. The bonnet is vented to the atmosphere. If the bellows ruptures, the valve operates like the Standard valve.

CERTIFIED AND APPROVED. Both Standard and Bellows Valves are approved under ASME Unfired Pressure Vessel Codes and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

LOOK INSIDE the Consolidated Safety Relief Valve. Fewer functional parts and precision machining and alignment of parts assure long valve life and less maintenance. Economical "2 in 1" design permits the Standard valve to be converted to the Bellows type right in your own shop.

There is only one adjusting ring—it can be set easily *before* valve installation to obtain peak performance at 4-5% blowdown. *Full-rated relieving capacity* is certain at all positions of the ring because a fixed maximum secondary orifice provides full lift at 10% over-pressure. *Valve action is consistently positive* even where "superimposed" back pressure is in the relieving system.

The temperature-compensating disc eliminates seat distortion caused by temperature-induced stresses — always seats tightly even when reasonable strains of unanchored discharge piping are present. A minimum guiding area is provided to align the seating surfaces — less chance of a sticking disc holder when corrosion or contamination build up on the guiding surfaces. The seating surfaces are optically-ground flat for easier, more economical servicing.

The contours of the huddling chamber and secondary orifice take full advantage of the stream pressure and kinetic forces. No other valve has this safety feature. Note the low placement of the threaded section that holds the nozzle in the valve. It assures high resistance to discharge piping strains — no leakage resulting from strain induced into the nozzle.

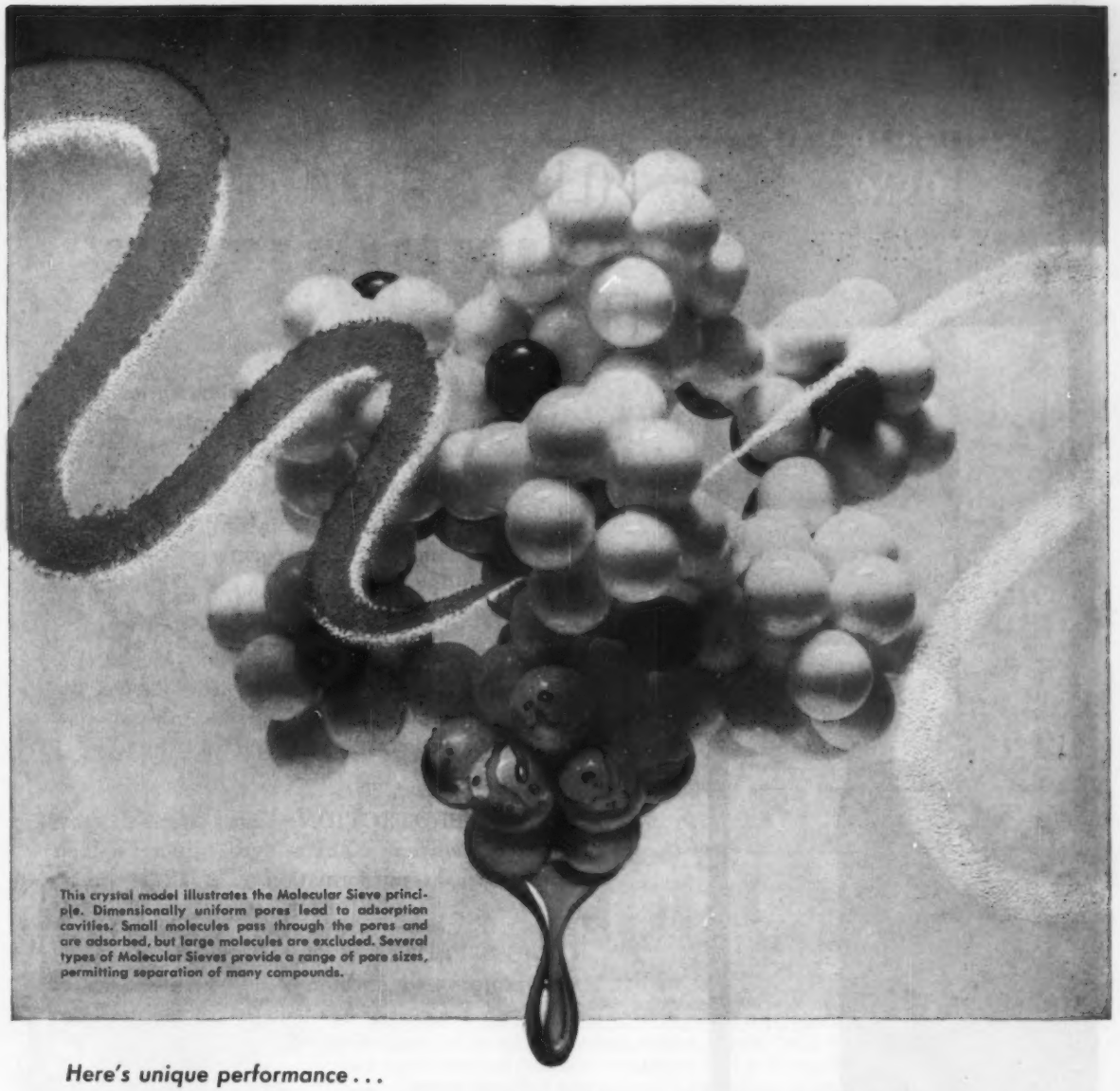
BE SURE OF ABSOLUTE PROTECTION for personnel and equipment — plus low maintenance. Select Consolidated Safety Relief Valves. Full range of sizes and pressures available with standardized inlet and outlet face-to-face dimensions for easy interchangeability with the valves of some other manufacturers. *Write for Catalog 1900.*

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario.*

CONSOLIDATED SAFETY RELIEF VALVES

A product of **MANNING, MAXWELL & MOORE, INC.** TULSA, OKLAHOMA

MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.* AIRCRAFT CONTROL PRODUCTS, *Danbury, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*



This crystal model illustrates the Molecular Sieve principle. Dimensionally uniform pores lead to adsorption cavities. Small molecules pass through the pores and are adsorbed, but large molecules are excluded. Several types of Molecular Sieves provide a range of pore sizes, permitting separation of many compounds.

Here's unique performance . . .

Molecular Sieves for Purification and Recovery!

. . . selective removal of contaminants, at temperatures up to 300°F!

. . . selective recovery of valuable stock without regard to relative boiling points!

Molecular Sieves, a new class of adsorbents developed by Linde Company, offer selective separation of gas or liquid mixtures in three ways . . . difference in molecule size . . . or polarity . . . or carbon bond saturation. And, co-adsorption can be utilized to remove several impurities simultaneously.

Typical uses? Removal of catalyst poisons from olefins . . . or extraction of olefins from refinery streams and top gases . . . or simultaneous dehydration and sweetening of natural gas . . . and many, many others.

LINDE Molecular Sieves offer new performance advantages . . . for many production uses. You may be able to lower costs, simplify processes, improve a product with this unique adsorbent. Find out more by writing for data describing Molecular Sieve properties and performance characteristics, Dept. PR-9, Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

The terms "Linde" and "Union Carbide" are registered trade-marks of Union Carbide Corporation

Linde TRADE MARK MOLECULAR SIEVES

UNION CARBIDE

For more data on advertised products, use Readers' Service Cards, last page.

announcing new UOP #5-S* INHIBITOR

5 ways better!

1 MOST POTENT of all gasoline antioxidants. Absolute protection from gum formation and TEL decomposition in stored gasolines.

2 MOST VERSATILE inhibitor-sweetener. Handles even gasolines formerly considered "impossible."

3 MOST RAPID sweetening action. *One-fourth to three-fourths faster* oxidation of malodorous mercaptans means a more flexible operation, less storage equipment needed.

4 MOST PROTECTION against engine deposits because phenylene diamine type eliminates their primary cause, gum formation.

5 MOST ECONOMICAL. *Five* molecules of UOP #5-S protect and sweeten a *million* molecules of gasoline . . . a cost of less than ½¢ per bbl.

Universal Oil Products Company has pioneered in the development of products and methods for better, more economical gasoline finishing. If you have a stability or quality problem, drop us a line and we'll be glad to help you to a solution.

*Trademark

Products Department

UNIVERSAL OIL PRODUCTS COMPANY

30 Algonquin Road, Des Plaines, Illinois, U.S.A.

ARE YOU SETTING UP TO HANDLE ETHANOLAMINES?

The lower costs and easier handling that result from bulk purchasing are encouraging many ethanolamines users to install bulk facilities. The checklist below lists the important installation factors, and Jefferson's bulletin on Ethanolamines* covers handling and storage information in considerable detail.

But there's an easy way to evalute the economies of bulk purchasing . . . and to plan a suitable handling system. Just call in your Jefferson representative and let him do it for you.

ETHANOLAMINES* *Send for your copy today!*

ETHANOLAMINES

. . . solidify at or slightly below room temperature. They will darken on exposure to air, and are hygroscopic. Iron and its oxides are relatively inert to ethanolamines, but copper and its alloys react to form complex salts.

Recommended are:

- Carbon steel storage tanks
- Heating coils of stainless steel
- Transfer lines at least 2" in diameter
- Pumps with all-iron parts

Color restrictions or temperature conditions may require:

- Nitrogen gas padding in storage
- Insulation of tanks
- Steam tracing of transfer lines

If used in aqueous solution, dilution in storage will lower the freezing point and reduce the viscosity.

Quick service on mono-, di- or triethanolamine is available from Jefferson's conveniently located stock points. **Jefferson Chemical Company, Inc., 1121 Walker Ave., Houston 2, Texas**

Essential Chemicals from Hydrocarbon Sources

Jefferson
CHEMICAL COMPANY, INC.

HOUSTON • NEW YORK • CHICAGO • CLEVELAND • CHARLOTTE • LOS ANGELES

For more data on advertised products, use Readers' Service Cards, last page.

sweetens effectively
at one-tenth the cost
of hydrotreating

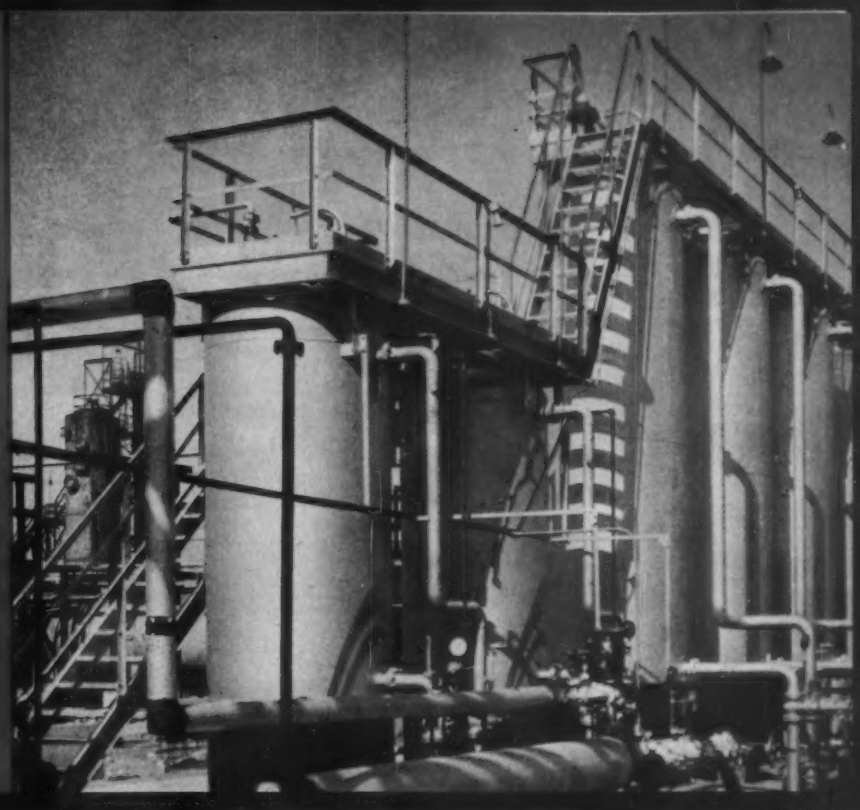
PETRECO-BENDER

catalytic sweetening
for kerosine, gasoline, burning oils

The installation cost of Petreco-Bender catalytic sweetening is only about one-tenth that of hydrotreating. Operating costs are only about 20% of the costs of conventional doctor treating. There are no product losses except those incident to sampling and spillage.

In addition to these obvious economic advantages, the Petreco-Bender process is simple to operate and maintain.

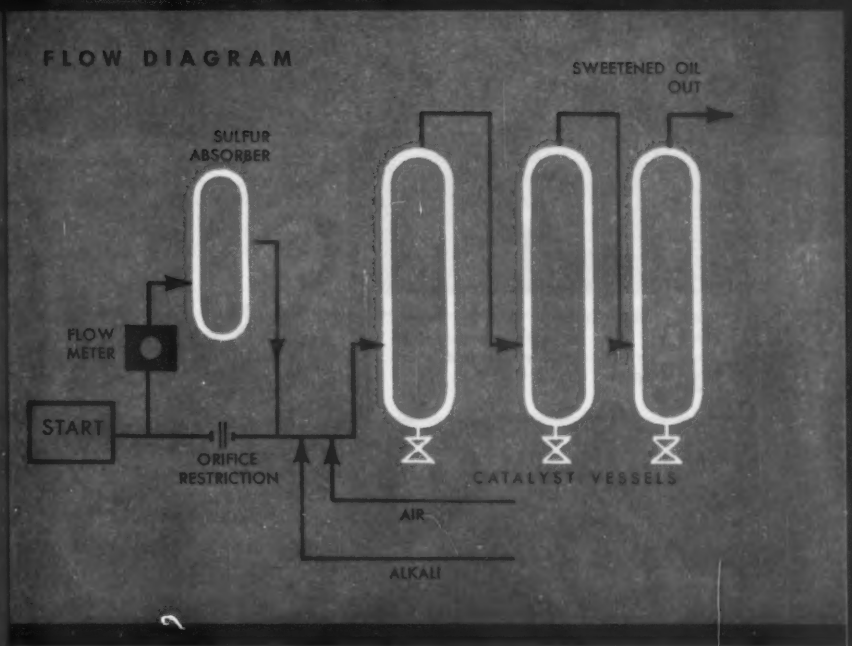
Low capital investment
Minimum operating costs
Negligible product loss
Continuous process
Automatic control
No copper contamination
Long catalyst life
Sweet, non-corrosive product



Typical Petreco-Bender catalytic sweetening plant. This plant is capable of treatment at the rate of approximately 6000 barrels per day.

HOW PETRECO-BENDER CATALYTIC SWEETENING OPERATES

Controlled quantities of sulfur, alkali and air are added to the product stream. The mixture is then passed through a lead sulfide catalyst bed. Sweetening is accomplished by converting the mercaptans to disulfides by oxidation. The treated product is sweet and non-corrosive. Operation is continuous, with automatic controls.



The Petreco Service Engineer in your area will gladly give you complete information. Or, just write or call

PETRECO

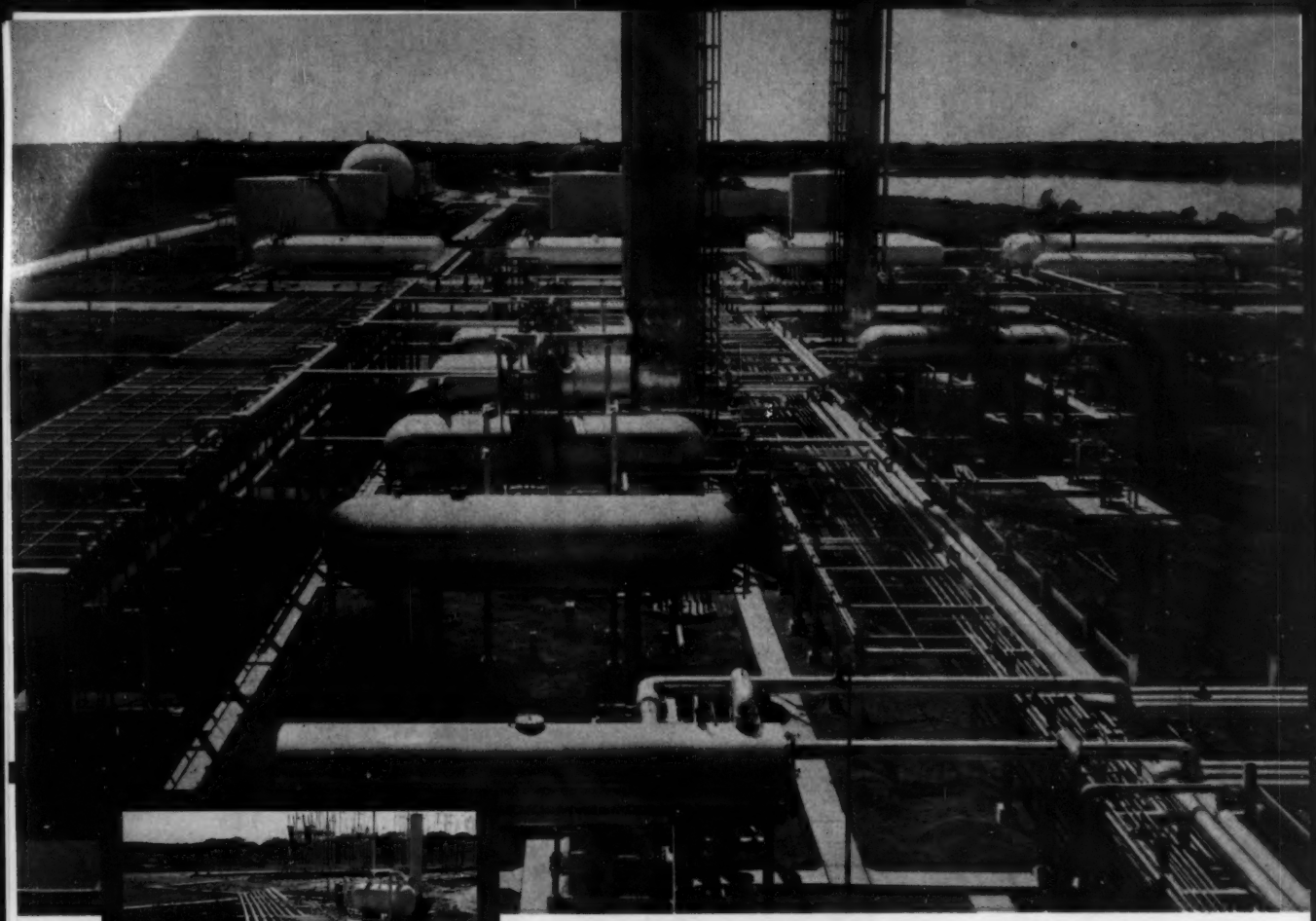
A DIVISION OF PETROLITE CORPORATION

3202 South Wayside Drive, Houston 1, Texas
1390 East Burnett Street, Long Beach 7, California

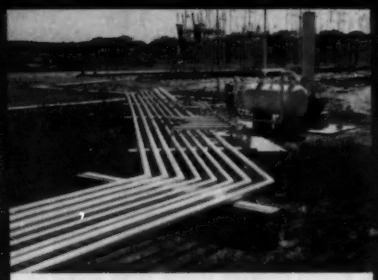
Specialized Electric Petroleum Treating

DESALTING • DEHYDRATING • CAUSTIC WASHING • ACID TREATING
DOCTOR TREATING • SWEETENING • NAPHTHENIC ACID REMOVAL
SEDIMENT REMOVAL

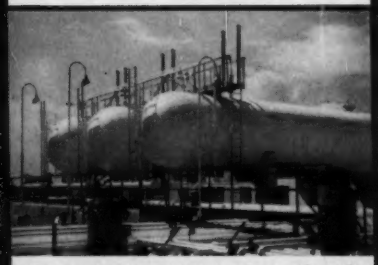
8-57-1



Three-coat systems of Normal Copon self-cleaning white tank coating and three-coat systems of Normal Copon aluminum tank finish were used to protect this fractionating plant of The Bay Petroleum Corp. (a subsidiary of Tennessee Gas Transmission Co.).



Copon pipe coatings provide thicker films per coat for extra protection of seams, welds, sharp edges and other trouble spots.



Copon tank coatings remain tough and elastic when subjected to heat, high humidity and chemical fumes.

Tanks stay whiter, brighter... protected by Copon coatings

Coatings of Normal Copon provide superior protection for tanks, pipes, and miscellaneous plant equipment. They cling tenaciously to metal surfaces, withstand the expansion and contraction of metal, and provide longer-lasting film integrity to assure permanent corrosion protection. Expensive surface preparation is not required when Copon-protected tanks are repainted, and Copon Coatings have the slowest rate of erosion in the industry.

Copon®

FOR CORROSION CONTROL

For complete information on Copon, write on your company letterhead to the manufacturer located nearest your city.

BENNETT'S.
65 W. First South St., Salt Lake City 10, Utah

WALTER N. BOYSEN CO.
42nd & Linden Sts., Oakland 8, Calif.
2309 E. 15th St., Los Angeles, Calif.

BRITISH AMERICA PAINT CO., LTD.
P. O. Box 70, Victoria, B. C., Canada

BROOKLYN PAINT & VARNISH CO., INC.
50 Jay Street, Brooklyn 1, N. Y.

COAST PAINT & LACQUER CO.
P. O. Box 1113, Houston 1, Texas

ENTERPRISE PAINT MANUFACTURING CO.
2841 S. Ashland Ave., Chicago 8, Ill.

INDUSTRIAL PAINT MANUFACTURING CO.
P. O. Box 2371, Birmingham 1, Alabama

KOHLER-McLISTER PAINT CO.
P. O. Box 546, Denver 1, Colo.

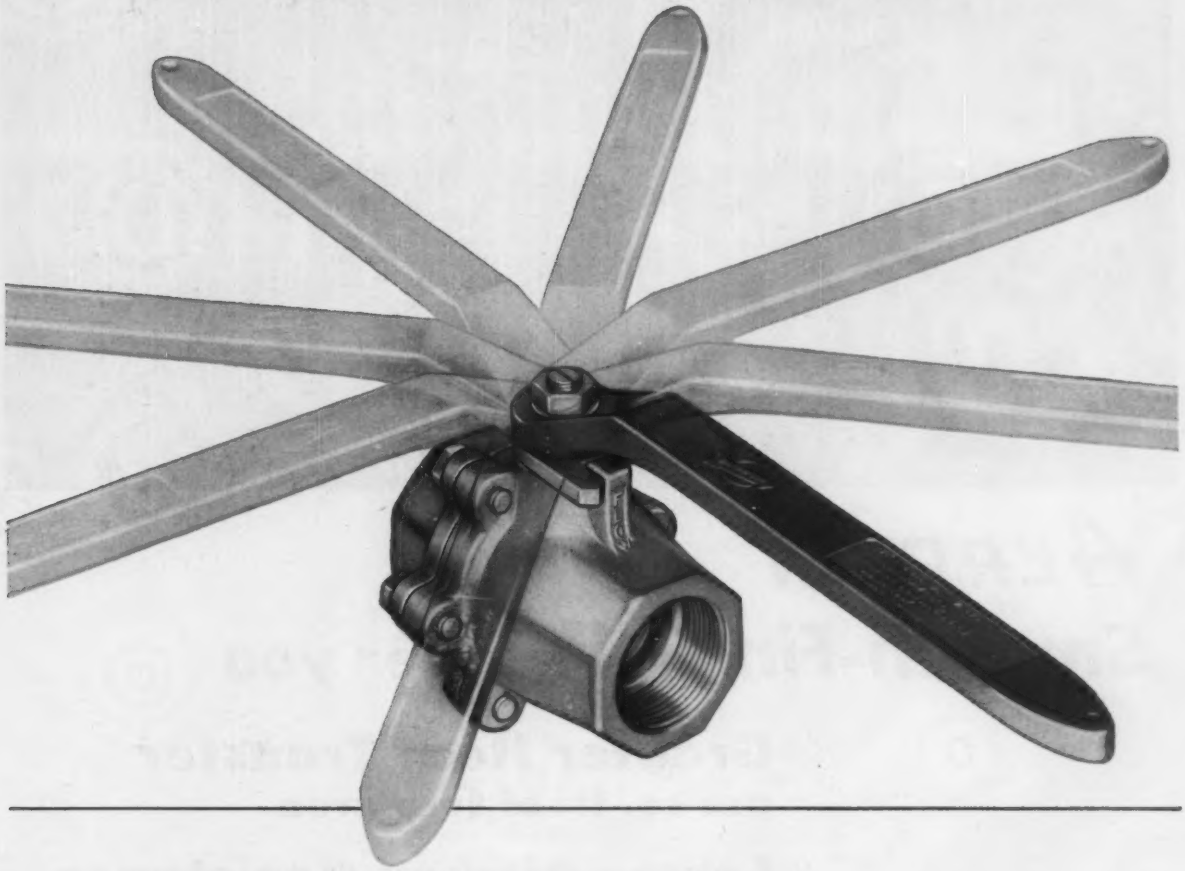
McDOUGALL-BUTLER CO., INC.
2929 Main St., Buffalo 14, New York

JAMES B. SIPE and COMPANY, INC.
P. O. Box 8010, Pittsburgh 16, Pa.

COAST PAINT & LACQUER De MEXICO, S.A.
Apartado Postal No. 9637, Mexico, D.F.

New Rockwood Forged Ball Valves

8 Ways Easier to Handle!



New Rockwood Ball Valves are made of forged brass for greater tensile strength and safety. You're assured of Full, Round Flow and fast, efficient operation and less friction loss too.

The handle of the new Rockwood Forged Ball Valve can be positioned in 8 different ways *giving you greater convenience.* The ¼ turn opens and closes the valve — *giving you Full, Round Flow, efficient operation, less friction.* The pressure of fluid in the Rockwood Forged Ball Valve automatically positions the ball against the synthetic rubber seat — *giving you a leakproof seal.* The forged brass ball in the Rockwood Forged Valve is chrome-plated to stand up under abrasion, pitting, scratching — *giving you trouble-free service.*

The new Rockwood Forged Ball Valve comes in pipe sizes from ⅜" to 2". Tested and listed by Underwriters' Laboratories, Inc. Mail the coupon now for complete specifications and information.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

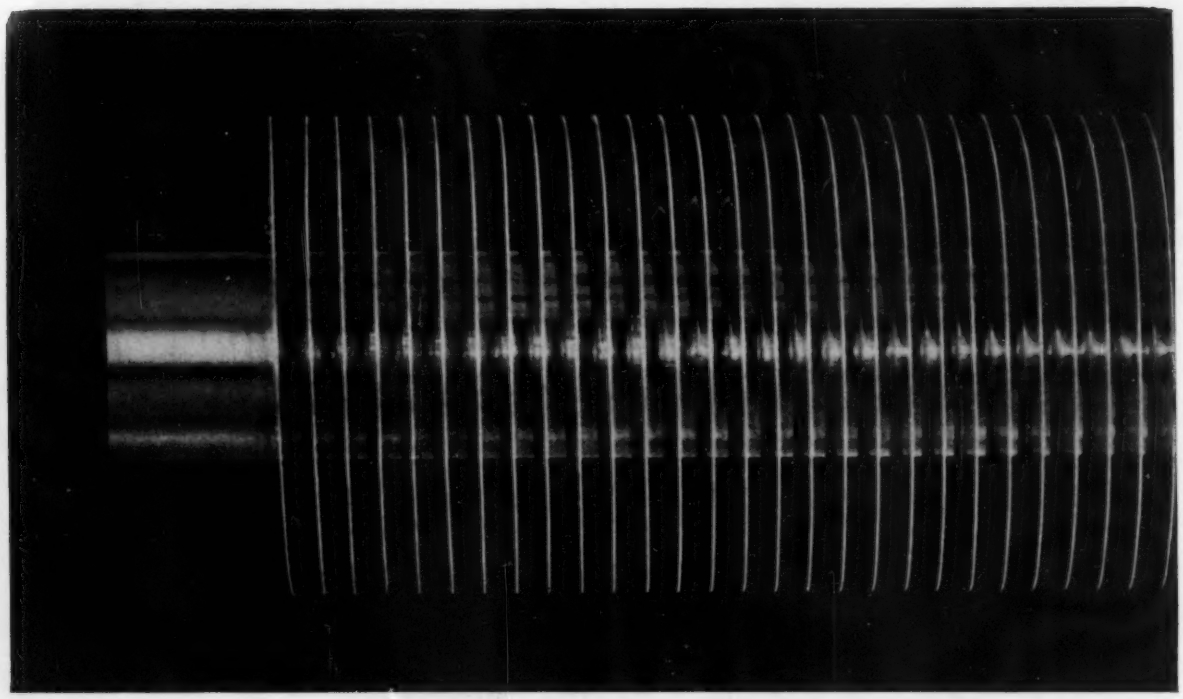
ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
2224 Harlow Street
Worcester 5, Mass.

Send me illustrated folder on Rockwood Full, Round Flow Ball Valves.

Name.....
Title.....
Company.....
Street.....
City.....
Zone....State.....

For more data on advertised products, use Readers' Service Cards, last page.



AEROFIN
Smooth-Fin Coils offer you

Greater Heat Transfer
per sq. ft. of face area

Lower Airway Resistance
—less power per c.f.m.

Aerofin smooth fins can be spaced as closely as 14 per inch with low air friction. Consequently, the heat-exchange capacity per square foot of face area is extremely high, and the use of high air velocities entirely practical. Tapered fin construction provides ample tube-contact surface so that the entire fin becomes effective transfer surface. Standardized encased units arranged for simple, quick, economical installation.

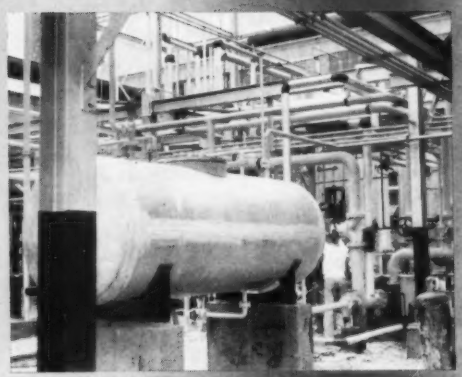
Write for Bulletin S-55

AEROFIN CORPORATION

101 Greenway Ave., Syracuse 3, N. Y.

Aerofin is sold only by manufacturers of fan system apparatus. List on request.

In Aluminum too...



Installation of aluminum piping for handling ammonium nitrate.

...a three-way saving in your piping dollars

When you specify TUBE-TURN* products, you are sure of getting the exact fittings for your job because the Tube Turns' line is the world's most complete . . . *you save engineering time.* Your welders can work faster because fittings are completely identified and perfectly uniform . . . *you save construction time.* You can buy all your fittings with one order from your nearby Tube Turns' Distributor . . . *you save purchasing time.* Are *you* getting these savings in piping costs?

*"TUBE-TURN" and "tt" Reg. U. S. Pat. Off.

The Leading Manufacturer of Welding Fittings and Flanges

TUBE TURNS

LOUISVILLE 1, KENTUCKY

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago • Detroit • Atlanta • New Orleans • Houston • Midland • Dallas • Tulsa • Kansas City • Denver • Los Angeles • San Francisco • Seattle. **IN CANADA:** Tube Turns of Canada Ltd., Ridgetown, Ontario • Toronto, Ontario • Edmonton, Alberta • Montreal, Quebec.

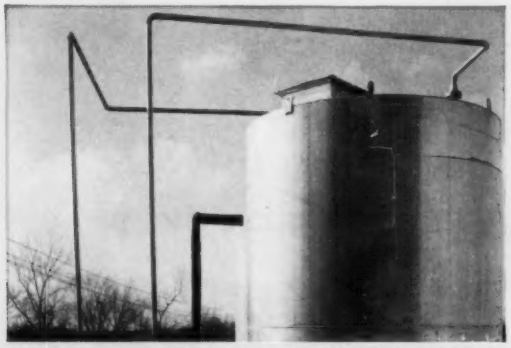
OTHER APPLICATIONS SHOWN ON REVERSE SIDE

In Aluminum piping too...

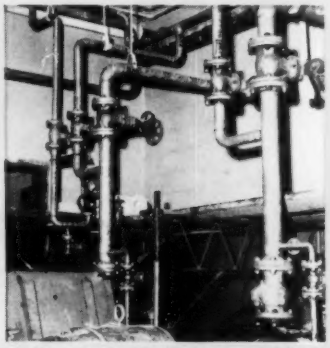
You save manhours with the line of 12,000 TUBE-TURN® products

LIQUID SUGAR. Part of welded aluminum piping system for processing of liquid sugar. When you specify TUBE-TURN* products, you can count on getting the right type, size, schedule and material for every piping service. Saves engineering manhours.

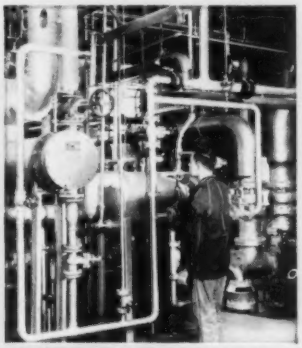
"A-POWER." These TUBE-TURN Aluminum Elbows are for nuclear swimming pool reactor water-coolant lines. Tube Turns' experienced engineering service helps you solve piping problems of all kinds. Contact your nearby Tube Turns' Distributor or District Office.



OLEIC ACID. These welded aluminum lines for oleic acid storage show how this strong but lightweight construction can be utilized for corrosive service. Your nearby Tube Turns' Distributor can give you complete-line service promptly . . . to help you save purchasing time.



REFINERY CATALYST is handled by this aluminum piping, equipped with TUBE-TURN welding fittings and flanges. Uniformity of TUBE-TURN products saves construction manhours



PURE WATER. Passive aluminum piping guards against contamination in this water purification plant. You can buy *all* your fittings with *one* order when you specify TUBE-TURN products.

NEW BOOKLET—This new Tube Turns' catalog gives helpful information on aluminum pipe, fitting and flange materials. Mail the coupon for your free copy.

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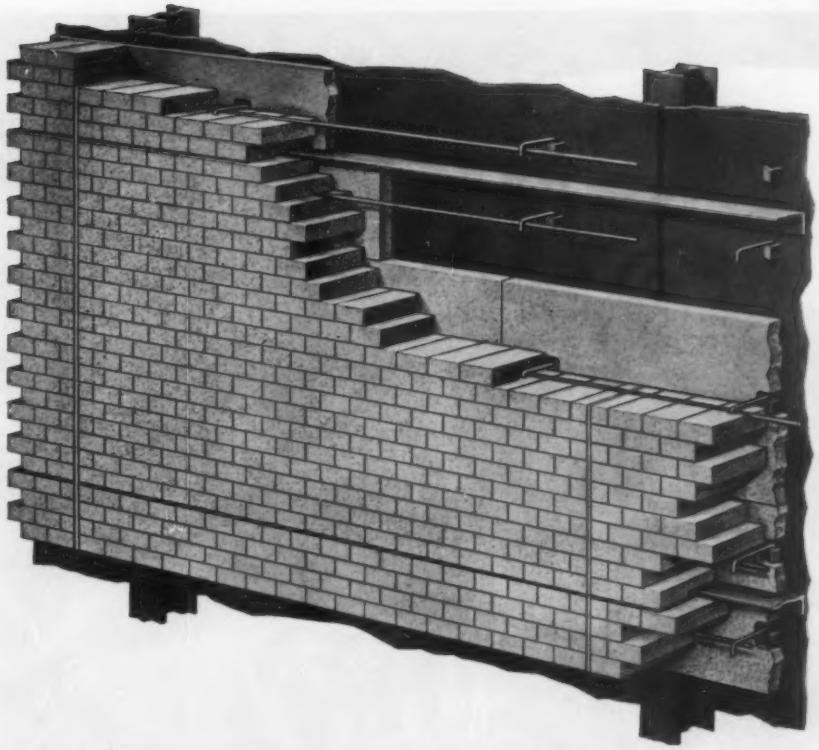

B&W Insulating Firebrick sectionally supported wall construction, horizontal rod-type anchoring

Can this construction cut your costs?

Simplified design and lower material costs in initial construction, ease of installation and maintenance, reduced downtime and economy of operation—these are the benefits of this *lightweight* insulating firebrick construction.

Here's what lightweight means. Compared with dense fireclay refractory materials that weigh from 125 to 140 lb per cu ft, lightweight insulating firebrick weigh approximately 26 lb per cu ft for B&W's 2000 degree brick. This difference provides two major advantages: (1) mechanical, which largely affects design and construction, and (2) thermal, which saves in maintenance, downtime and operation.

Savings in design and construction

The use of lightweight IFB simplifies engineering requirements and reduces costs. A minimum of detailing is needed, since the design is engineered around one standard shape — a feature of B&W IFB constructions.

Material requirements are simplified, too. B&W IFB can be tailor-cut, drilled or shaped as necessary, eliminating the need for costly special fired shapes, and the delays in obtaining them. Typical sections, such as burner openings, observation ports and tube supports, can be cut and shaped on the job in minutes, using ordinary woodworking tools.

Substantial savings are possible in structural steel, since insulating firebrick roof and wall constructions are lighter. In locations with soil of poor load bearing capacities, this lightweight may also result in reduced foundation costs.

These savings, coupled with B&W's engineering and service facilities available during the design phase, mean lower initial costs.

Savings in maintenance, downtime and operation

Lightweight IFB offer a major thermal benefit—they store and conduct less heat. Heavy refractories retain heat; in the event of forced shutdown, they can cause burn-out of expensive alloy tubes, where used. The low quantity of heat stored by B&W IFB can be quickly dissipated, thus protecting these expensive tubes.

Further, this low heat storage permits faster heating and cooling. This means quicker access to the furnace in the event of emergency shutdown. Your maintenance crew can get in the furnace sooner and get it back on stream faster.

Supplied from nearby warehouses

With the use of simplified IFB constructions, refractory repairs can be quickly and easily accomplished with standard shapes from a nearby warehouse. This eliminates costly delays in obtaining special shapes.

Anchoring devices, too, are simplified. Since there are no expensive special castings in B&W IFB constructions, carbon steel or low alloy rods can be used. These are generally available from any local steel warehouse.

Increased efficiency

Generally, the lighter a firebrick the better an insulator it is. Since B&W IFB are the lightest insulating firebrick made, they are the most efficient insulators. Per inch of thickness, B&W IFB provide more insulation than any other refractory material. The result is that for walls of equivalent thickness less heat is lost with B&W IFB. Casing temperatures are lower, thus improving working conditions. This means increased efficiency and reduced operating costs.

R 930

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For more data on advertised products, use Readers' Service Cards, last page.

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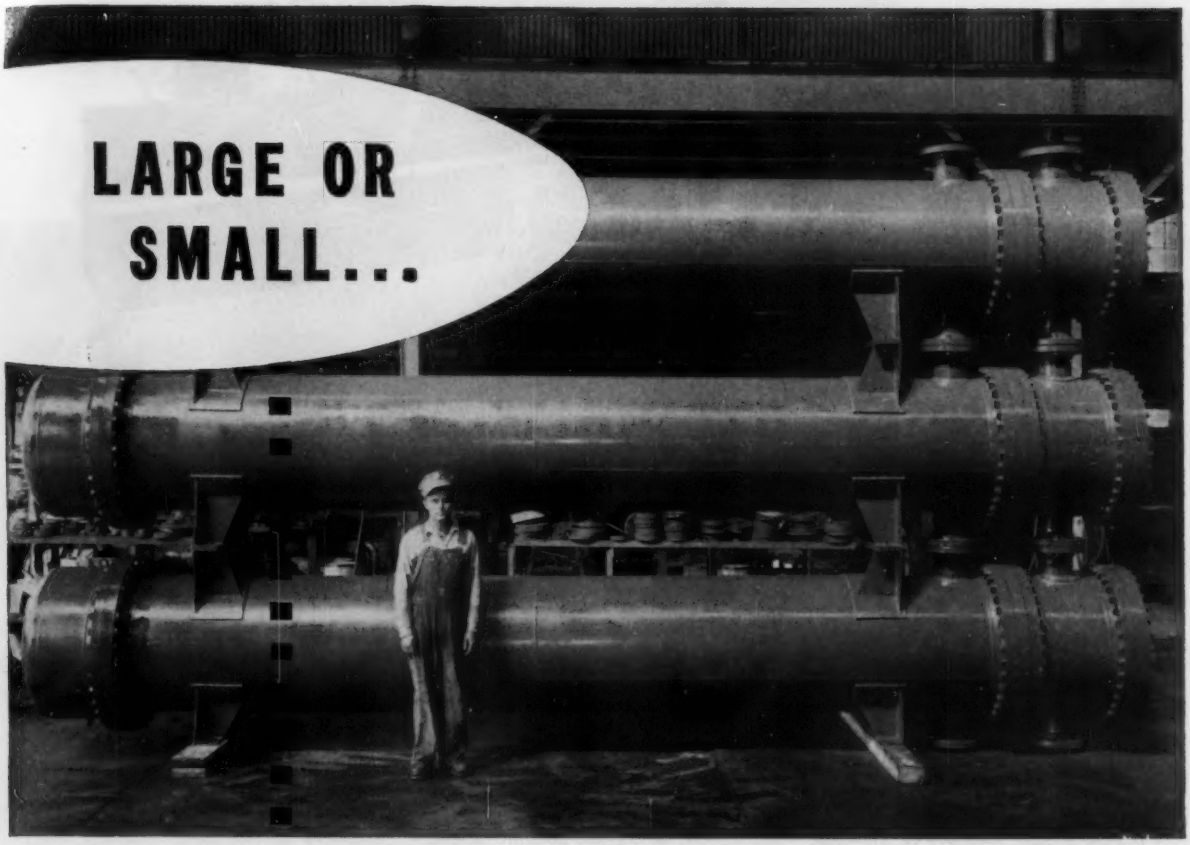

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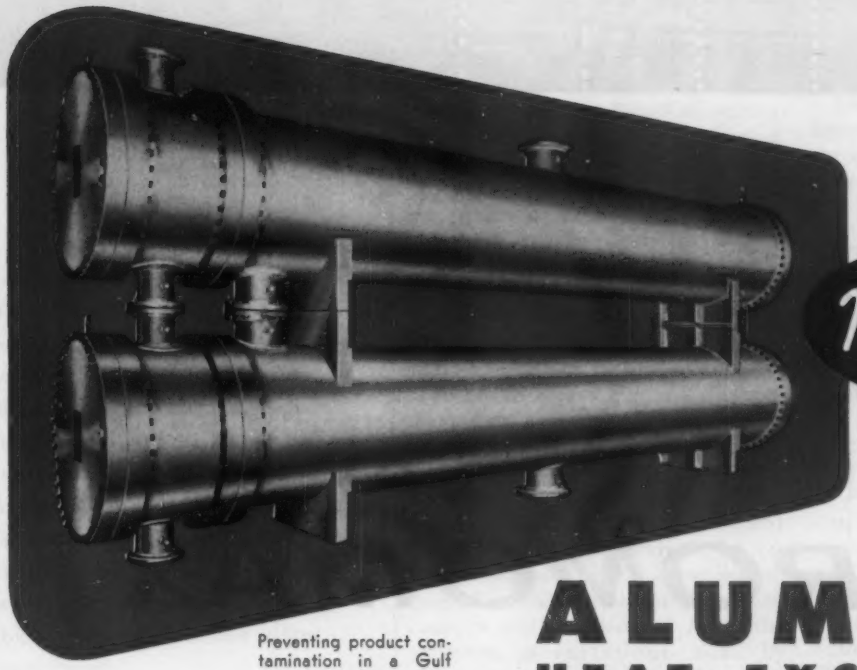
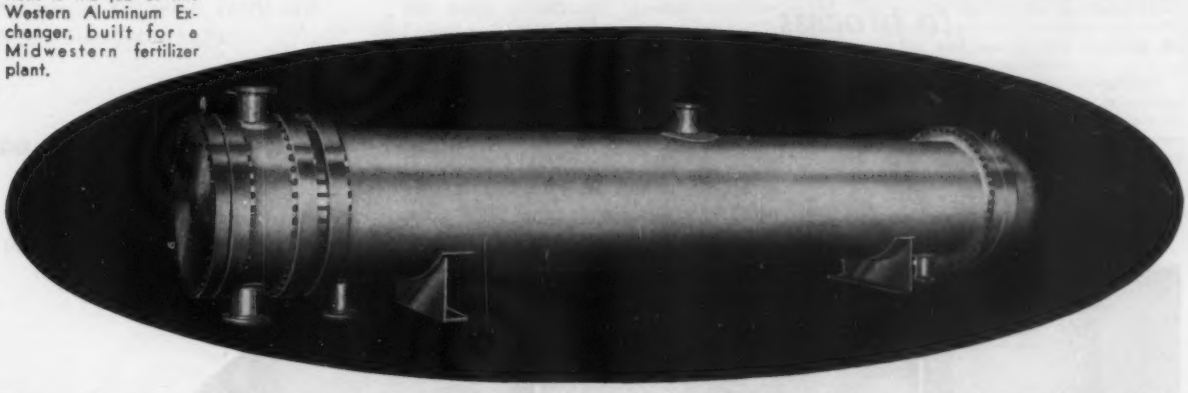


SPECIAL *Metallurgy*

ALUMINUM HEAT EXCHANGERS from WESTERN

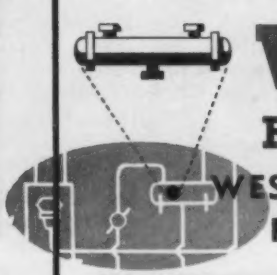
Preventing product contamination in a Gulf Coast high density polyethylene plant is the application for which these Western Aluminum Exchangers were designed.

Corrosion resistance to ammonium nitrate solutions is the job of this Western Aluminum Exchanger, built for a Midwestern fertilizer plant.



Exemplary of Western's experience in special alloy fabricating are these all-aluminum exchangers—wherein Western's metal inert gas and tungsten inert gas welding equipment, along with other specialized equipment and facilities—are utilized to produce heat exchangers specifically designed for handling specific corrosive fluids. Western's background in special metals has been successfully applied to Austenitic Stainless Steels —High Chrome Irons—Low Chrome Moly Steels— Monel—Copper Silicon—Nickel—and Aluminum.

You can profit from Western's extensive metallurgical experience. All we need is the opportunity.



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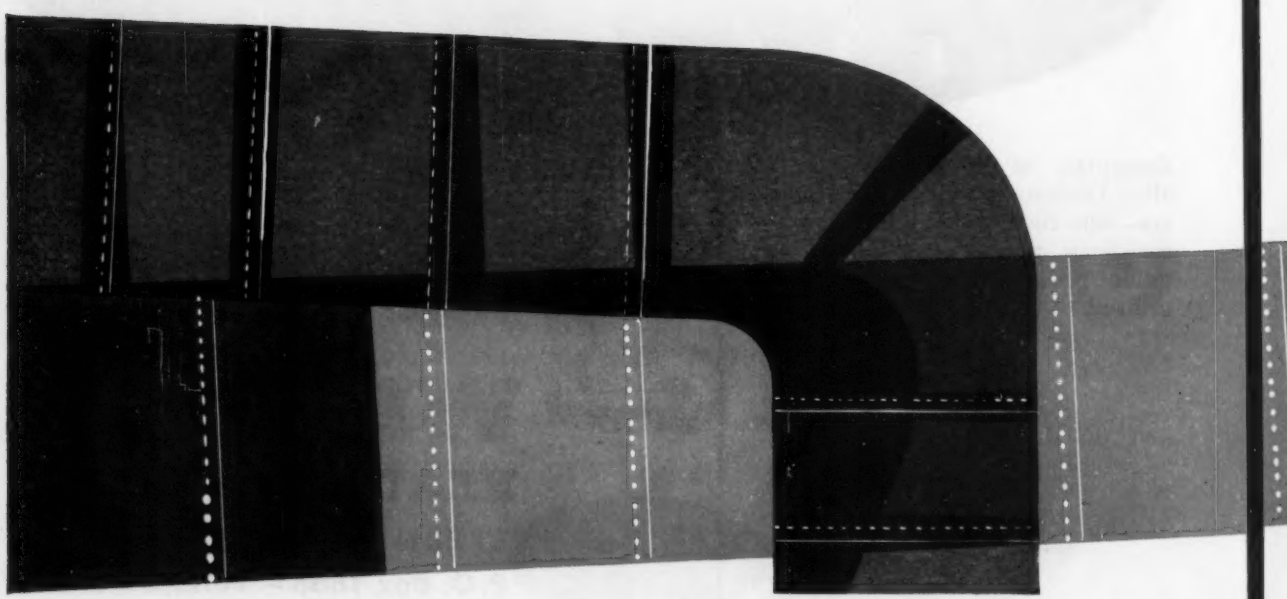

Probing deep into the heart of process streams, the Chromomax can be the difference between profit and loss. This new advance in gas chromatography instrumentation will be of vital interest to engineers and plant managers alike. An analysis by Chromomax brings into focus the variations of all stream components which contribute to profitable or to unprofitable plant production.

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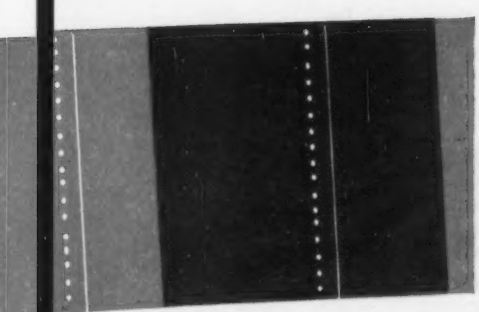
Instruments *Automatic Controls*



The Mail Box . . .

Mechanical Seals

To the Editor:

With reference to Part 3, appearing in the April issue, we must advise that while we warmly welcome Mr. Harold Woodhouse's efforts for the cause of the mechanical seal ("Centrifugal Pump Packings and Seals" series early this year in PETROLEUM REFINER), we do not agree with the analyses or terminology applied to the hydraulic principles of the balanced mechanical seal.

In his reference, Figure 2, he very adequately describes an unbalanced mechanical seal. Figure 3 is then described as a partially balanced seal. In this case, we do not concur, as Figure 3 is also an unbalanced seal and differs from Figure 2 only to the extent of providing a narrow sealing face. The unit face loadings in both cases, would be identical (with the exception of variations caused by clearances and tolerances). The total face loading would of course, be directly proportional to the face area and hence, the frictional heat output would also vary accordingly which is the basic advantage of the narrow-faced seal. Since the unit loading is either equal or greater than the pressure sealed, by agreed definition the seal manufacturers would describe both of these as unbalanced seals.

Figure 4 on the other hand is, as the author indicates, a totally balanced seal. This is a theoretical condition and would not however, be utilized in actual practice except in very unusual instances. Here the author further states "in practice, seals are purposely not completely balanced, a 10 to 15 percent out-of-balance is preferred." This principle is correct but the figures are not in accordance with conventional practice as standard hydraulically balanced pump seals will vary from approximately 60 to 85 percent overbalance, depending on the manufacturer, service, and operating conditions to be considered.

Harold F. Greiner,
Providence, R. I. Sealol Corporation

Author's Comment

Mr. Greiner has made some excellent comments. He is quite correct, technically, in stating that Figure 3, described as a partially balanced seal, is really still an unbalanced seal; it is partially balanced with respect to load only. It is probably unfortunate that the seal company with which I have done the most business, refers to this type as partially balanced, when that remark really applies to load only.

The 10 to 15 percent out-of-balance figure which I quoted was given to me as a general figure by another seal manufacturer.—Harold Woodhouse

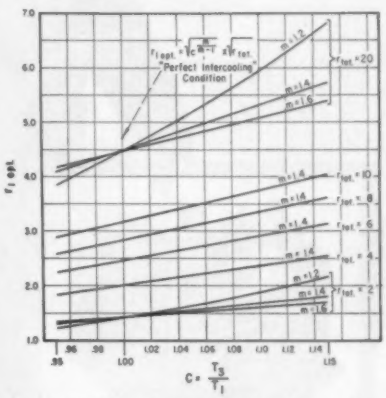


Figure 3. The effect of suction temperature ratio vs. optimum pressure ratios is shown.

Arrow Needed

To The Editor:

. . . There is one discrepancy ("Selecting The Intercooler Pressure," W. A. Rostafinski, July '57) on Figure 3, Page 192. The words "Perfect Intercooling Condition" pertain to the ordinate on $c = T_2/T_1 = 1.00$ and not to the formula on the top of that figure, as shown.

W. A. Rostafinski

NOTE—The author is correct in calling our attention to this error. The figure is repeated above with an arrow, shown dotted, included to indicate the line of perfect intercooling.—Editor

"Cathodic Protection"

To the Editor:

Might not it have been editorially more accurate to publicize the article (June PETROLEUM REFINER) about magnesium anodes, by the gentlemen from The Dow Chemical Company, as a handbook on the use of magnesium anodes for cathodic protection, rather than an all-inclusive Cathodic Protection Handbook? The article is not a handbook to cathodic protection, but rather a handbook on the usage of one particular material of one particular type of anodic materials.

Your all-inclusive title undoubtedly seduced some readers into reading the article. It hardly seems fair to your readers, and certainly isn't fair to all your advertisers to throw the weight of your publication behind the product of one particular manufacturer.

It is most probable that the gentlemen from Dow agree that there are circumstances in which other materials are equally as applicable as magnesium. It is also probable that, the opinion of the editors of PETROLEUM REFINER notwithstanding, there are certain applications in which other materials and other types of anodes perform much more efficiently and economically than magnesium.

James W. Metzger,
Dayton, Ohio Duriron Company, Inc.

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A Quick Look at the Industry THIS MONTH

Tight Year for Small Refiners . . . '57 trend to cut back gasoline stocks has hurt the independents. Those without established markets, depending mostly on large oil companies as outlets, have been particularly hard-hit. Because of this and other factors, a number of small refineries are on the selling block.

To make matters worse, Military Supply Agency recently announced it will reduce purchases on all refined products (principally Navy special fuel and avfuel) from 10 to 15 percent in fiscal year '58. (See Page 392.) Loss in sales may be as high as $170 million.

Government and industry spokesmen are questioning Military's decision. Say small refiners will be subject to "serious economic hardship." Reason: Independents whose contracts are cancelled with only a portion of deliveries made to Defense Department will be caught with substantial quantities of specialized fuels which have no commercial market.

Outlook for Gasoline Stocks . . . Although still high, gasoline stocks are starting to improve. On August 16, total stocks were about 4 million barrels under the same period in '56. Gasoline demand has moved about 4.6 percent ahead of '56. (See Page 187.)

BuMines predicts September gasoline demand will average 4 million bpd, crude runs 7.8 million bpd. Refiners will have gasoline yield of 44 percent.

Polyethylene Sales Shoot Upward . . . Now running a close third, polyethylene may pass second place styrene in plastics sales next year. Vinyls will remain firmly emplanted at top of the heap.

With stiff competition and expanding markets as stimulus, total plastics production should exceed 4 billion pounds in '57.

Postings on Octane Race . . . Premium gasoline octanes averaged 98.1 for August, 0.1 below July. Regular maintained its July level, averaging 90.9.

No let up is in sight for octane competition. Sun Oil Company just made another move to stay ahead. Company's service stations have introduced new premium gasoline in Florida and southern Georgia, bringing total number of grades to six.

'58 auto engine compression ratios will range as high as 10 to 1. Predictions are ratios will continue to climb at rate of about half a point a year for next few years. Result: By '60, high performance cars will require 110 octane gasolines.

New Trends in Lube Oils . . . How to rate viscosity of various oils was major discussion topic at recent meeting of American Society of Testing Materials in Atlantic City. With so many overlapping ratings in use now, a plea was made for single standardized method. Several societies are lending weight to the proposal: American Society of Testing Materials, American Society of Lubrication Engineers, American Society of Mechanical Engineers, American Petroleum Institute.

Race to improve lube quality, product cleanliness and stability, is speeding trend toward hydrogen treating. Refineries will use up all hydrogen obtained from naphtha reforming in '57. Look for more hydrogen facilities to be built in '58 to meet growing demand.

Example of growth: '57 production of higher quality hydrogen treated lube oil will be nearly 3½ times greater than last year, averaging 250,000 bpd.

Oil Company Earnings Up 17 Percent . . . That is 43-company average increase in first half of '57 over same period in '56. However, upward trend will be curbed in second half. Reasons: Crude production, exports and refinery runs will be reduced—weakening product prices—increases in labor and materials cost.

Quick Glance at Washington . . . Rocky road lies ahead for government-proposed import plan—predictions are that elimination of one inequity (six oil companies are protesting quotas allotted them) may create another, starting a chain reaction which might sign program's death warrant . . . **Harris Bill decision** is out for this session—expected to have better chance of passage when Congress re-convenes in January . . . **Next phase of Roosevelt Committee investigation** will cover surplus gasoline and the effect it has on gas wars—one target will be gasoline made from "cheap" foreign oil . . . **Finally made public,** O'Mahoney Subcommittee majority report thoroughly rapped oil industry's "planned programs of cartelized nature, import policies, buyer proration and pipe line monopolies"—latter blast included poke at use of controlled pipe lines to restrict sources of oil to independent refiners.

New 100-Million-Barrel "Field"—Sans Crude Oil . . . A 100-million-barrel field was formally added to U. S. petroleum reserves early in August. However, crude is not the basic product. For first time in its history, the U. S. oil industry witnessed start-up of $16 million operation designed for commercial recovery of high quality oil products from a substance other than crude. Gilsonite is the new basic product.

Refinery can handle 700 tons of gilsonite daily, produce 1300 barrels per day of high quality gasoline and 250-275 tons per day of high grade metallurgical coke, plus plant fuel and gas. New enterprise is owned by American Gilsonite Company which is jointly owned by Standard Oil of California and Barber Oil Corp.

Report on '58 Cars . . . Fuel injection will be offered as optional equipment on 20 models . . . **At least one auto maker** will push six-cylinder models, stressing fuel economy in move to combat competition from foreign "bugs" . . . **84 percent of the new cars** will be equipped with V-8 engines . . . **About half** will need premium fuels . . . **Reversing long time trend to smaller crankcases,** '58 versions will have greater oil capacity.

Cool Off With Oil . . . If successful, oil-fired air conditioning may mitigate summer slack season for home heating oils. Servel, Inc. has developed heating and air conditioning plant for average-size homes. Firm is selling 100 units in the New York-New Jersey area this summer. If pilot sales operation proves out, Servel predicts the industry will be selling 450,000 units annually by '60 and over one million in '65.

Oil Industry Needs $115 Billion for Expansion . . . This amount will be spent in next 10 years to supply increasing demands of non-Communist world. Economists predict that by '67 domestic demand will have risen to more than 14¼ million barrels a day, and demand in the rest of the free world will be almost as high. They expect the U. S. will be supplying 11 million barrels a day.

During past 10 years, '47-'56, expenditures by entire oil industry for capital investments and exploratory purposes have totaled $69 billion, about $47 billion or 67 percent in the U. S. and the remainder in other countries.

Asphalt Market Looks Promising . . . U. S. asphalt demand will probably reach 136 million barrels annually by '62, three times greater than in '46. Paving asphalt will account for about 105 million of this total due to $100 billion federal highway program.

Plan to curb U. S. imports may run counter-wise to road building program. Large portion of U. S. imports are heavy crudes and residual fuels—both in high demand in the U. S.

New Fields Show Promise . . . Seventy new oil fields were discovered during July. Among the most promising were: Cheyenne Oil's strike flowing 1350 barrels of 40-gravity oil a day in Montagu County, North Texas; Continental's Andrews County, West Texas, discovery making 1345 barrels of 37-gravity.

HAVE YOU GOT THE FACTS ABOUT YOUR BUSINESS?

It's surprising how little oil's customers know about the biggest selling petroleum product—gasoline! They never see it or touch it—yet they *use* it every day. All they know is the price they pay . . . and only a few know how big a bargain they really get with today's gasoline.

You'll be helping yourself and your industry by giving oil's customers the *real* story about today's gasoline prices and taxes. Here are the facts:

Direct Taxes add 40 cents to every dollar spent for today's gasoline!

When you hear the phrase "gasoline prices are high," this is your best reply: "Gasoline *taxes* are high, but gasoline *itself* is a bargain!" Yes, it's true that for every dollar spent for gasoline, an additional 40¢ must be paid for federal and state gasoline taxes!

Mr. Average American Motorist—who drives his car approximately 9,360 miles a year—pays $56.76 in direct taxes on gasoline alone! That's an average of 8.8¢ a gallon—a rate four times higher than the federal 10% tax on "luxuries" like mink coats!

But let's look at the price of gasoline *itself*. Gasoline has gone up only a few pennies, in the last five years. Meanwhile, gasoline quality has improved tremendously, so that today's *regular* gasoline is as good as premium gasoline was only five short years ago. And today's *premium* gasoline is as powerful as the bomber and fighter gasolines of the last war.

So next time you are asked about gasoline prices, remember . . .

WITH TODAY'S GASOLINE YOU DRIVE THE BEST BARGAIN IN YEARS!

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50 W. 50th St., New York 20, N. Y.

I would like to obtain more information about today's gasoline quality, prices and taxes. Please send me your FREE booklets.

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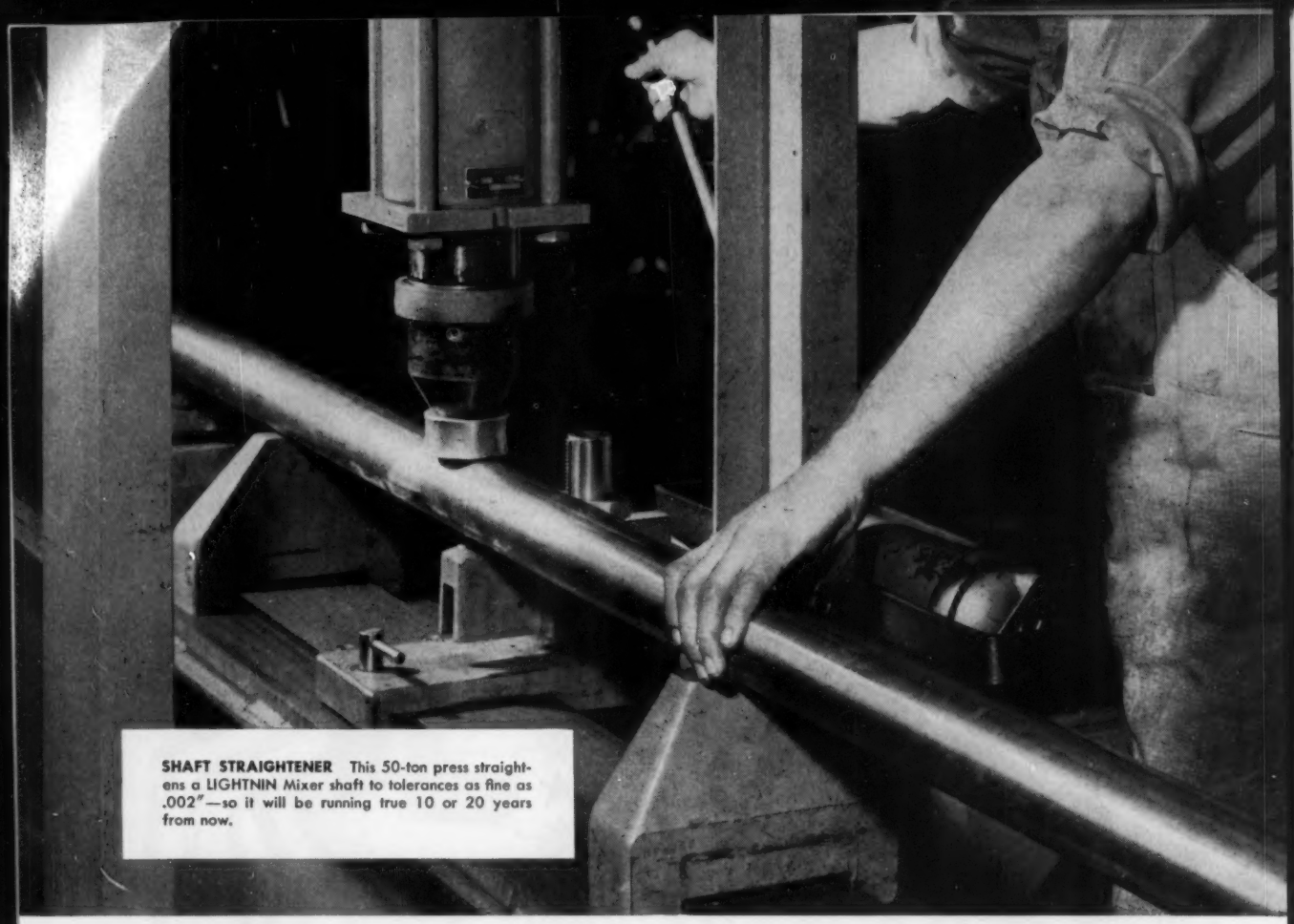
For more data on advertised products, use Readers' Service Cards, last page.



SHAFT STRAIGHTENER This 50-ton press straightens a LIGHTNIN Mixer shaft to tolerances as fine as .002"—so it will be running true 10 or 20 years from now.

How to prevent **shaft failure** *when you mix fluids mechanically*

An out-of-line shaft on a mechanical mixer can be bad for your process, in more ways than one.

A shaft that bends or breaks may not cost much to replace—but can cost plenty in downtime. Even a slight misalignment in the shaft can set up stresses leading to shaft breakdown. And an off-true shaft makes it impossible to operate a stuffing box or rotary mechanical seal efficiently.

Importance of straightness

That's why every LIGHTNIN Mixer shaft must pass the test shown above, so it will run true when it gets into your tank.

The *shaft straightness* you get when you specify LIGHTNIN Mixers means several important economies.

For example, you can use two different metals in the same two-piece rigidly coupled shaft: corrosion-resistant alloy in the tank, plain steel above the splash line. This two-piece construction has many other advantages; it's possible only because of the most careful straightening and machining.

Know what shaft will do

You can draw on a wealth of cost-cutting shaft application data, too, when you mix with LIGHTNINS. What's the most economical shaft diameter that lets you skip the upkeep of a submerged steady bearing in the tank bottom? How can you avoid paying for excessive "safety factor" in an overhung shaft that must run smoothly during draw-off? We can give you the right answers, quickly and without guessing—based on thousands of test runs in a uniquely equipped fluid mixing laboratory.

This extra care in shaft design and application is just one example of a *way of thinking* that goes to work for you when you unload a fluid mixing problem on a specialist engineering firm like MIXCO.

It's one more reason why you get surer, more efficient fluid mixing—better process results — when you specify LIGHTNIN Mixers.

For quick, competent help on fluid mixing operation, call in your LIGHTNIN representative. He's listed in Chemical Engineering Catalog. Or write us direct.

Lightnin® Mixers

MIXCO fluid mixing specialists

SHAFT DEFLECTION TEST records the play of fluid forces on LIGHTNIN Mixer impeller and shaft. Data permit accurate prediction of shaft critical speeds, and most economical shaft selection for a given mixing job.

FOR LATEST MIXING INFORMATION and full description of LIGHTNIN Mixers, send for these helpful bulletins:

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- ☐ B-111 Quick-change rotary mechanical seals for pressure and vacuum mixing
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Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 164-j Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd., Toronto 10, Ont.

Down With the 20th Century Idol!

DURING THE TIME it takes you to read this editorial (about 3½ minutes), nine people will be injured in traffic accidents. Property damage will total $11,918.

One violent traffic death is occurring every 13 minutes.

A proportionate share of the injuries and deaths are attributable to oil industry personnel, despite heavy investments in money and manpower to curb the heedless slaughter.

In the words of a leading oil company's safety director, "The biggest industrial safety problem our company has is traffic accidents. In fact, our most severe personal injuries result from human failure behind the wheel."

As a group, oil industry safety experts say the basic problem can be traced to a generation of people who don't know how to drive. They have been raised in an era of power. Horsepower first—driving ability, caution and courtesy a poor second.

"American motorists have not been taught to respect their '20th Century Idol.' Proper driving attitude has not been instilled in the peoples' minds. They have been, and are being taught hit-or-miss driving methods." These are the experts' observations.

If the desires of the buying public are any criterion (and observing the seemingly prevalent belief that those desires cannot be changed), the horsepower idol will continue to be worshipped indefinitely. It is now generally conceded that if the growing toll of traffic injuries and deaths is to be reduced far greater emphasis must be placed on two areas, both designed to improve driving ability and attitude. Those areas are:

- On the job safety.
- Off the job safety.

On the Job Safety. The oil industry can be justifiably proud of the leading role it has taken in reducing on the job traffic accidents. Every large company and most of the small ones have some form of driver training program. Nearly all have incentive awards for outstanding driver safety records. Many sponsor competitive driving events such as truck roadeos.

As a result, last year the oil industry had a commendable accident frequency rate of .81 per 100,000 miles of vehicle travel.

That record can be improved. To give but one example, in 1949 one large oil company had an accident frequency rate of .78 per 100,000 miles. That same year the company started a program with much greater emphasis on driver training sessions, competitive driving events, incentive awards and traffic safety talks at employe meetings. The program has improved and expanded every year since. Today that same company's accident frequency rate is .3 per 100,000 miles, far under the industry average.

Another company set up a program with emphasis in the same areas. It has cut its accident frequency rate 20 percent.

In both instances much of the credit for the improved safety records is given to top management, as well as safety departments. The company leaders believe in the sound premise that to be successful a safety program must work from the top down. Management must give enthusiastic support and leadership before it can possibly hope for the employes to respond.

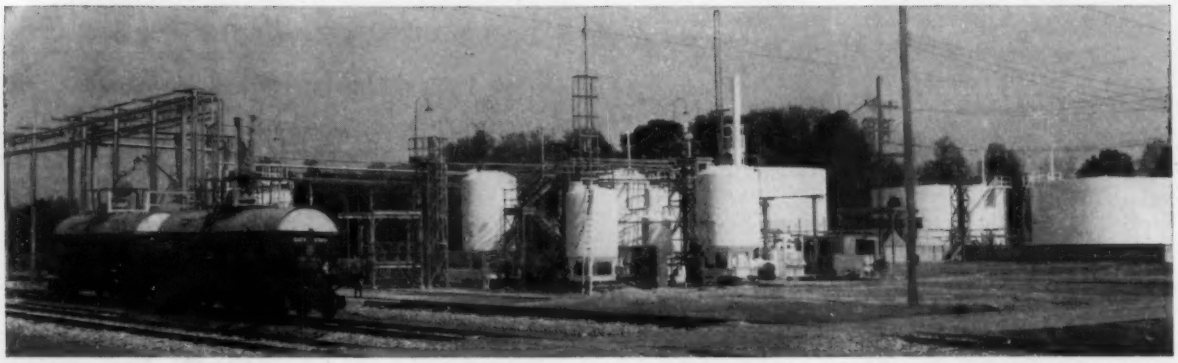
There is no reason why more oil companies can't improve their traffic safety records by using the same ideas and policies.

Off the Job Safety. Some oil companies and most industry groups have made outstanding contributions in this area also. The Oil Information Committee has taken a definite stand in support of traffic safety programs in several states. The American Petroleum Institute gave active support to the campaign which resulted in curbing promotion of speed and power in automobile ads.

On a company basis, many firms invite the entire family to attend employe safety meetings, encourage employe participation in local, county, state and national safety organizations and give active support to public school driver training programs.

One company gives 50,000 driver handbooks to public schools every year. A number of oil industry safety personnel head safety groups on all levels, even help out with school programs.

But, that is not enough. Even though a number of oil companies have worked hard to reduce traffic

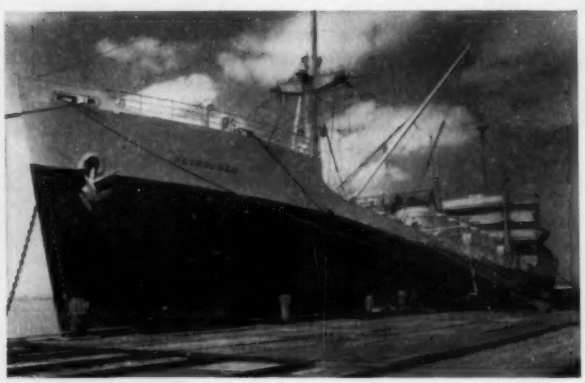


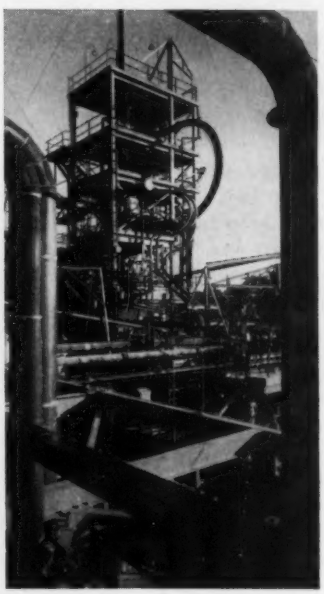
HERE IS the new Du Pont tetraethyl lead terminal at Beaumont, Texas. This latest addition to the rapidly expanding facilities insures an ample nearby supply, and prompt filling of orders from Gulf Coast refiners. The terminal contains complete modern equipment for storage and handling, and rapid dispatch of loaded TEL tank cars. The new terminal will be kept amply supplied with TEL by tank ship from the Du Pont manufacturing plant at Deepwater, New Jersey.

Three major expansions of Du Pont TEL facilities—already completed in 1957

Already this year Du Pont has opened a large new storage terminal, commissioned a new ship and opened a new manufacturing plant.

MV PETROCHEM, first ship to transport TEL compound in bulk, is another major addition to Du Pont's setup for delivering tetraethyl lead. Built primarily to supply the Beaumont TEL terminal, she is also equipped for transporting ethyl chloride and ethylene dichloride on northbound sailings. For maximum safety, the 6,000-ton tank ship is permanently compartmented, with solid bulkheads dividing the operational and cargo sections.





THIS NEW DU PONT TEL manufacturing plant at Antioch, California, was completed by Du Pont early this year. It was constructed to meet the needs of the fast-growing West Coast refining industry. Incorporating the most modern TEL manufacturing facilities in the world, it makes possible fast, short-distance shipments of California-made TEL to all West Coast refineries.

THESE THREE major expansions will increase even more the efficiency of the nationwide network of Du Pont TEL facilities. They complement the Chambers Works TEL manufacturing plant, the Du Pont Petroleum Laboratory, the five regional Petroleum Chemicals laboratories, the conveniently located rail sidings with loaded tank cars in 14 major refining areas, and the 12 sales-service offices. Like the wide range of services—technical, marketing, research, safety and operational—offered by Du Pont, the purpose of these installations is to help you get the most out of our additives program.

DU PONT
REG. U. S. PAT. OFF.
Better Things for Better Living
. . . through Chemistry

Petroleum Chemicals

E. I. DU PONT DE NEMOURS & CO. (INC.) · Petroleum Chemicals Division · Wilmington 98, Delaware

accidents, much more can be done. Not just *some,* but *all* companies should start with top management and work down in a concentrated effort to reverse the mounting traffic toll in dollars and lives.

The goal looks easy on paper: Simply start a downward trend from the 40,000 deaths (one every 13 minutes) and the 1.4 million injuries (nine went on the books while you were reading this far) that resulted from traffic accidents in 1956. To bring about the downward trend poses a major challenge for everyone.

Several oil companies have already proved it can be done.

So, why doesn't the oil industry lead the way in making the automobile a safe, obedient helper instead of a worshipped, highly destructive idol?

It could be a big feather in our cap.

Let the Horns Sound

THE OIL INDUSTRY is noted for its conservative policies, particularly when it comes to tooting its own horn. And judging from recent newspaper, union and government attacks, someone in the industry needs to toot something.

A thorough, honest job of creating better public understanding of oil's operations is needed badly. An ideal focal point for such a project is just around the corner.

That focal point is Oil Progress Week, October 13-19. For seven days nearly two million oil industry employes will have a golden opportunity to report to friends and neighbors on the industry's contributions to the nation's progress, plans for the future and the problems involved in keeping 165 million Americans supplied with a vital natural resource.

As in previous years, the success of OPW will depend on the number of volunteers who have enough sincere interest in the future of their industry to roll up their sleeves and work. OPW needs your help. You can do your part by volunteering at your nearest area OIC office. If you don't have time for OIC work, then make it a point to spend at least a part of the week talking about oil to your friends and neighbors.

But, don't stop there. Follow up with your own personal 365-days-a-year public relations program. Tell everyone you know about oil's side of controversial as well as non-controversial subjects. A few letters to senators and congressmen on such issues as the Harris Bill and the depletion provision would help tremendously.

Commencing no later than Oil Progress Week, let the horns sound long and clear.

Demand to Improve Remainder of Year

DEMAND FOR petroleum in the U. S. is running ahead of last year's, but so far 1957's needs have not come up to expected levels. Additional gains in oil demand are expected in the final four months of the year, according to the Independent Petroleum Association of America.

Consumption of all oils (domestic and export) during the three months, May through July, failed to reach anticipated levels, the IPAA pointed out by reporting the average demand for the period amounted to 8,650,000 barrels daily, which was 125,000 barrels a day, or 1.5 percent, more than was used in the same period of last year. However, this rate was 250,000 barrels daily, or 2.8 percent, less than the Association's earlier forecast.

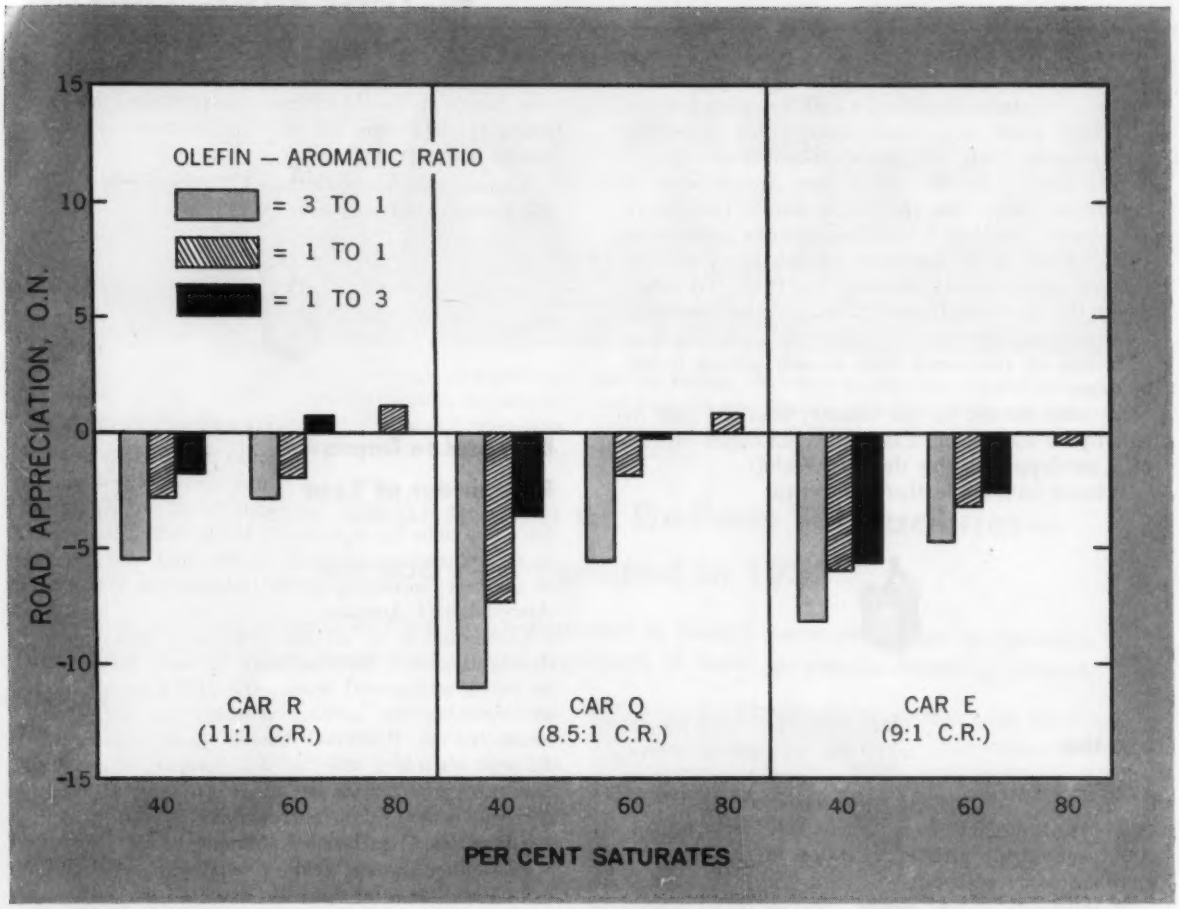
Assuming normal weather conditions, the IPAA estimated that total domestic demand for petroleum products during the last four months of 1957 will be about 9,400,000 barrels a day. That would represent an increase of 550,000 barrels daily, or 6 percent, over the same period in 1956 when the weather was warmer than normal.

The 6 percent gain in consumption mentioned above is for domestic usage only and does not include exports which must be considered when total demand for U. S. oils is calculated.

Exports in the four-months period are expected to average 330,000 barrels daily, for a decline of 275,000 barrels a day from shipments in 1956's period when the Suez Canal was closed. Adding these expected shipments to the above domestic demand estimates, the resulting total needs average 9,730,000 barrels a day, and that would be an increase of 275,000 daily, or 2.8 percent, over the 1956 rate, IPAA estimated.

Applied science in the form of the technological process is an inexhaustible source of new wealth.

—Dr. C. Guy Suits



Effect of hydrocarbon-type concentration on the road appreciation of leaded blends containing three hydrocarbon-types. Tests at 3000 RPM were made in two 1955 cars of conventional engine compression ratio and in one experimental model of 11-to-1 compression ratio

Ethyl Research Offers Refiners New Benchmark in Rating Gasoline Test Blends

Road Performance Predicted From Laboratory Data

BY F. D. BUERSTETTA, Refinery Technology Division, Ethyl Corporation Research Laboratories

A CONTINUING research program in Ethyl Corporation's Detroit Laboratories has produced new data that will assist refiners in blending their fuels for optimum road performance.

These data are available in a published report entitled, "Road Performance of Ternary C_7-C_8 Hydrocarbon Blends." It is the fifth in a series of progress reports on the program which is aimed at gaining a more thorough understanding of the principles relating gasoline hydrocarbon composition to road antiknock performance.

In this latest report, consideration of the effects of hydrocarbon-type concentration in various blends containing three hydrocarbon types in the C_7-C_8 range at two tetraethyllead concentrations forms the basis for discussion.

For more data on advertised products, use Readers' Service Cards, last page.

Binary Blend Testing Preceded Ternary Blend Studies

All four previous reports were based on the road antiknock behavior of 99 blends, each of which contained two types of pure hydrocarbons in the C_7-C_8 range.

These blends, composed of toluene and diisobutylene separately added to mixtures of isooctane and n-heptane, were extensively tested to find the relationships that exist between road performance and the fuel variables commonly defined by laboratory tests:

Hydrocarbon type and concentration, Research and Motor octane number, and TEL concentration.

An Ethyl Corporation Research team evaluates data obtained in the most recent study of the relationship of fuel variables to road performance.

The program's scope included numerous combinations of hydrocarbon concentration and TEL content at the Research octane levels of 92, 96 and 100, thus permitting several different approaches to the data analysis.

Blends considered in this most recent phase of the program also were of toluene and diisobutylene, representing aromatics and olefins respectively in saturate mixtures of isooctane and n-heptane.

These components were combined to give ternary blends containing 40, 60 and 80% saturate concentration with olefin-to-aromatic ratios of 1-to-3, 1-to-1, and 3-to-1 at each saturate level.

A nominal Research octane number level of 100 was maintained for all blends at TEL concentrations of 0.0 and 3.0 ml per gallon.

In order to provide comparisons with the binary blend studies, road ratings were conducted in the same 1955 passenger cars that were used in previous tests, (nominal compression ratios of 9.0-to-1 and 8.5-to-1).

The blends also were rated in a car having an 11-to-1 compression ratio engine to permit evaluation of performance in engines of the future. All data were interpreted in terms of "road appreciation" to give refiners a better idea of the effectiveness of each blend.

New Tests Confirm Earlier Conclusions

Test results of blends containing three hydrocarbon-types verified the previous conclusions based on binary blend studies — that hydrocarbon-type and concentration, Research and Motor octane number, and TEL level are the most important factors affecting the road performance of gasoline.

Analyses of test data produced these conclusions:

1. The addition of TEL from 0.0 to 3.0 ml per gallon significantly increased road appreciation in all cars over the speed range. This effect is greatest at high engine speed.

2. TEL generally has the greatest effects in fuels containing highest aromatic and saturate percentages.

3. Increasing aromatic content at constant saturate level results in increased road performance of the ternary blends in all cars.

4. With regard to road appreciation, the ternary blends vary—as did the binary blends—according to changing aromatic (or olefin) percentages.

5. Road appreciation is also related qualitatively to fuel sensitivity.

6. The hydrocarbon-type effect is most notable at high engine speeds in all of the test cars.

Results of the long-range program are made available to the refiner as the data are analyzed and reported.

Over-all Research Program Continues

These research findings are but another step forward in Ethyl's continuing effort to aid the refiner in blending fuels and predicting road performance without extensive road testing.

Right now, the long-range program is being carried forward to include all of the hydrocarbons falling within the gasoline boiling range. The results obtained in this important phase of the program will be made available for study by refiners in the near future.

How Ethyl Research is helping you

At today's high octane levels, the art of blending hydrocarbons has taken on ever-increasing importance. As a service to the Petroleum Industry, Ethyl Research launched its long-range hydrocarbon blending program in 1956 to complement the intensive Industry effort being devoted to the problem.

Since the program started, Ethyl has made available four technical reports: "Octane Possibilities with C_7-C_8 Hydrocarbons," "Octanes That Count," "TEL, Hydrocarbons and Road Appreciation," and "Road Performance of C_7-C_8 Blends via Computer Analysis."

Now a fifth report, "Road Performance of Ternary C_7-C_8 Hydrocarbon Blends," is available for your study. Copies of this—and any of the previously issued reports—can be obtained from your Ethyl Representative or by writing Ethyl Corporation, 100 Park Avenue, New York 17, N. Y.

ETHYL CORPORATION
New York 17, N. Y.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

RESEARCH LABORATORIES:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

For more data on advertised products, use Readers' Service Cards, last page.

F. J. Tompkins, Chief Design Engineer (right), Bernard Anik, Mechanical Engineer (left rear), Singmaster & Breyer, N. Y. C. Foreground, Michael De Piano, Cooper Alloy Corp.

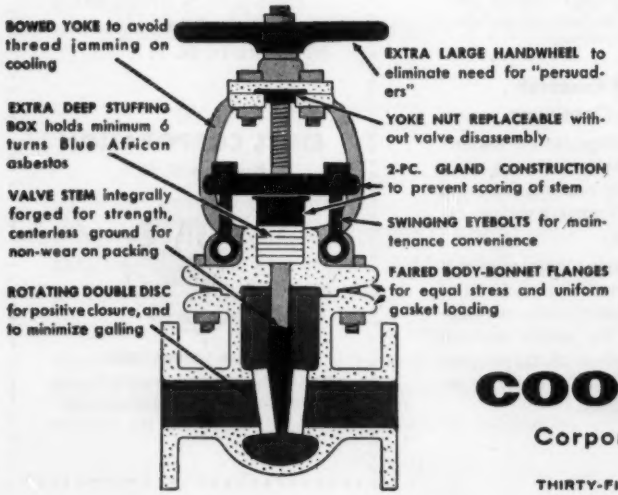
TOMPKINS and ANIK of SINGMASTER & BREYER

tell why they build Cooper Alloy stainless valves into their basic plant designs

Q. Gentlemen, precisely why do you buy Cooper Alloy valves?

FJT—With me, dependability is the main reason. My major concern is overall plant design, and frankly I don't have time to worry about every equipment detail. As specialists in designing and building "first-of-its-kind" processing plants, we need valves we can count on, and can "build in" as part of our original design. Cooper Alloy valves, we've found, fill that bill.

BA—From my point of view as a mechanical engineer, it's the Cooper Alloy valve *design* that appeals to *me*. It has extra features, like the extra-large handwheel, unique square compression of packing, bowed yoke, integrally forged stem, and others, all of which make for less maintenance and longer, more economical valve life.


BOWED YOKE to avoid thread jamming on cooling
EXTRA DEEP STUFFING BOX holds minimum 6 turns Blue Afrıcan asbestos
VALVE STEM integrally forged for strength, centerless ground for non-wear on packing
ROTATING DOUBLE DISC for positive closure, and to minimize galling
EXTRA LARGE HANDWHEEL to eliminate need for "persuaders"
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2-PC. GLAND CONSTRUCTION to prevent scoring of stem
SWINGING EYEBOLTS for maintenance convenience
FAIRED BODY-BONNET FLANGES for equal stress and uniform gasket loading

A VALVE DESIGNED FOR STAINLESS!

The Cooper Alloy valve is not an adaptation of earlier brass and iron patterns. Cooper Alloy, with over 35 years of experience in handling stainless steel, created a valve *designed to be cast in stainless!* **Check the Special Design Features shown at left.**

As the little CA man below is saying: "*You can tell a Cooper Alloy Valve as far as you can see it!*" Write today for *your* copy of our folder "Design Factors In Stainless Steel Valves." The Cooper Alloy distributor near you will be glad to show you the complete line of Cooper Alloy valves *and fittings*, and their advantages. He can serve you promptly from local stocks.

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Corporation • Hillside, New Jersey

VALVE & FITTING DIVISION

THIRTY-FIVE YEARS OF STAINLESS STEEL PIONEERING

Petroleum Refiner | PROCESS DEVELOPMENTS

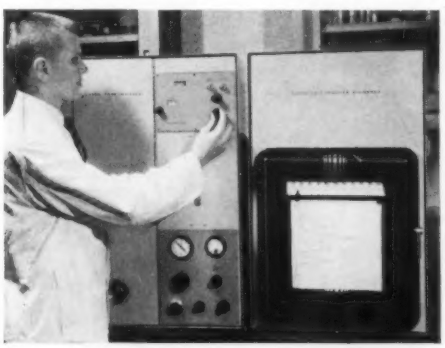
1957

Perkin-Elmer Announces 3 New Advances In Gas Chromatography

Since the advent of commercial gas chromatography instruments, Perkin-Elmer has been a leader in the development of new instruments and techniques. Now Perkin-Elmer announces three new instruments, each a unique advance in its field.

NEW! The Model 188 Triple Stage Vapor Fractometer
will analyze an unknown multi-component sample faster than any gas chromatography instrument in service today. The Model 188 makes three simultaneous analyses of high, medium and low boiling components, each under optimum chromatographic conditions. The instrument will analyze mixtures with components ranging from light gases to liquids boiling at 400°C. or higher.

NEW! The Model 184 Process Vapor Fractometer
performs continuous multi-component analyses of a wide variety of process streams. The instrument automatically withdraws samples from the stream at timed intervals and determines the concentration of from one to four pre-selected components, recording these with exceptional reproducibility on a bar chart. The Model 184 was evolved from experimental instruments placed in actual plant service by ten leading petroleum and chemical companies over a period of almost two years. Shown here is face of programmer unit.



NEW! The Model 154-C Vapor Fractometer
brings automatic range control to gas chromatography. The 154-C anticipates high peaks and automatically attenuates them to manageable proportions, leaving the operator free to go about other work. The Model 154-C also features two new accessories: a combustor for reducing complex hydrocarbons such as octane to CO_2 and H_2O for easier, faster determination; and a high-temperature column that handles liquids with boiling points up to 400°C.

For further information write us at 900 Main Avenue, Norwalk, Conn.

INSTRUMENT DIVISION

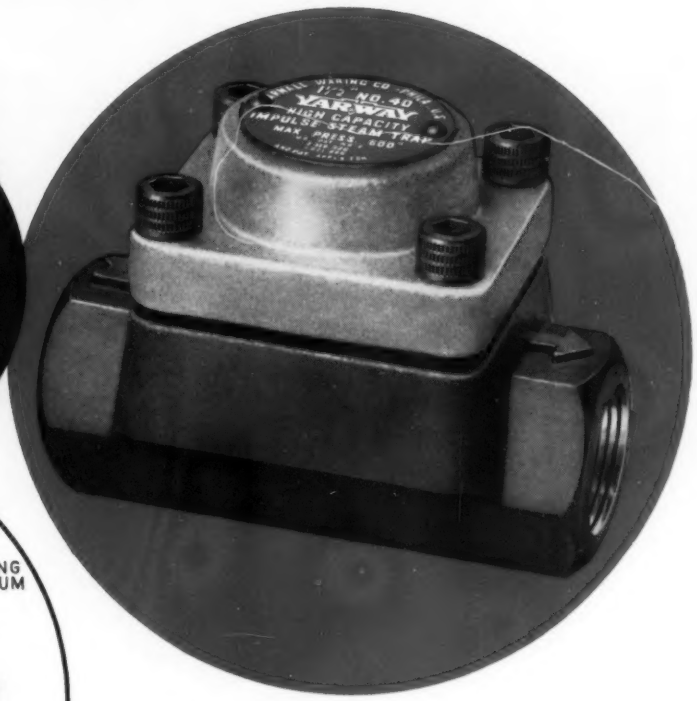
Perkin-Elmer *Corporation*

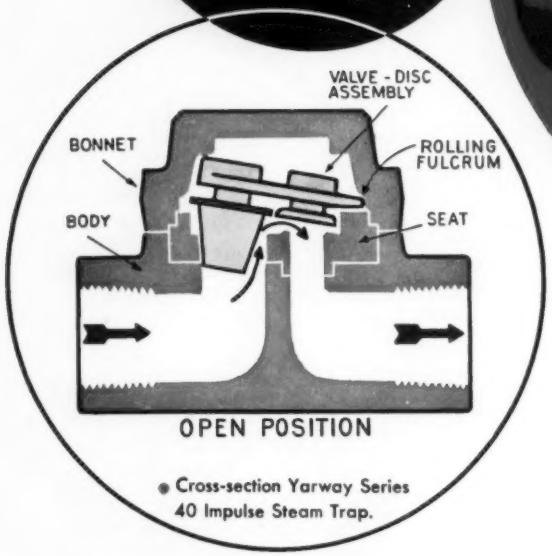
NORWALK, CONNECTICUT

See Perkin-Elmer products in Booth 1456 during ISA show Sept. 9-13, at Cleveland Auditorium

This YARWAY IMPULSE STEAM TRAP is for extra heavy* condensate loads

YARWAY SERIES 40





* Cross-section Yarway Series 40 Impulse Steam Trap.

The famous Yarway "impulse" principle of thermodynamics that revolutionized steam trapping many years ago, is now applied to a steam trap for extra heavy condensate loads—the Series 40 Impulse Steam Trap. Users report with this trap they obtain quicker heating, higher and more even temperatures in their process equipment.

It also incorporates all the other advantages of earlier Impulse trap designs, such as—immediate response to load changes, no air binding, light weight and small size. Maintenance is low, thanks to stainless steel body and working parts.

High condensate capacity of Yarway Series 40 Impulse Steam Traps makes them ideal for heavy condensate loads on large autoclaves, cooking kettles, dryers, heat exchangers, heating coils, presses, unit heaters, etc.

Suitable for all pressures up to 600 lbs. maximum, without change or adjustment. Operates against back pressures up to 50%. Five sizes, ½", ¾", 1½", 2" and 2½".

Your Yarway man will furnish a Yarway "40" for 90-day free trial in your plant without obligation, or write for Yarway Bulletin T-1746.

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.

*Examples: At 10 psig, ½", 1300 lbs./hr.; 2", 10,000 lbs./hr.
At 100 psig, ¾", 5600 lbs./hr.; 2½", 62,000 lbs./hr.

STANDARD SERIES 60 YARWAY IMPULSE TRAP

For normal steam trap applications the standard Series 60 Yarway Impulse Steam Trap is recommended. For *extra light* condensate loads use the ½" Yarway 20-A Impulse Steam Trap.

Send for Yarway Bulletin T-1739X.

YARWAY **IMPULSE® STEAM TRAP**

OVER 1,000,000 YARWAY IMPULSE STEAM TRAPS USED

For more data on advertised products, use Readers' Service Cards, last page.

THEY HELPED PLAN THIS ISSUE. A conference was held to establish the limits and type of material included in the 1957 Process Developments Issue. Attending the conference were these industrial experts, left to right: J. D. Walk, American Oil Company, El Dorado, Ark.; V. A. Kalichevsky, Magnolia Petroleum Company, Beaumont, Texas; Harold L. Hoffman, REFINER staff; D. E. Norris, Houdry Process Corporation, Philadelphia, and J. J. Maurer, Delhi-Taylor Oil Corporation, Corpus Christi, Texas.*

1957 PROCESS DEVELOPMENTS

TODAY, more than ever before, the busy refiner needs a handy reference to the latest process developments. Realizing this need, the PETROLEUM REFINER staff has spent the past months seeking the most authoritative answers to such questions as:

- What are the newest processes?
- How do they work?
- Will they perform as well on any kind of charge?
- What kinds of trouble are likely to arise during operations?

After many plant visits, meetings with experts and several months of research, the answers were found. You will find them all in the 15 articles on the following pages. Now, right at your fingertips, you will have a first-hand reference to the latest advances in process technology.

Following is a brief digest of the many timely subjects you will find in the 20th Annual Process Issue:

Hydrocracking, a means of upgrading fuel oils into more valuable materials, is another name for destructive hydrogenation. The three articles on this subject (p. 198, p. 201, and p. 205) represent the latest work both here and abroad.

Extremely high pressures (3000-10,000 pounds per square inch) were needed

* The attendance by executives, engineers, superintendents, and other employes of oil and petrochemical companies at these conferences does not constitute an endorsement of Petroleum Refiner over any other one publication. The fact that men of outstanding ability are allowed to attend these planning conferences shows the interest which the oil and petrochemical industry has in sound editorial content planned for the benefit of the industry and those who work in it.

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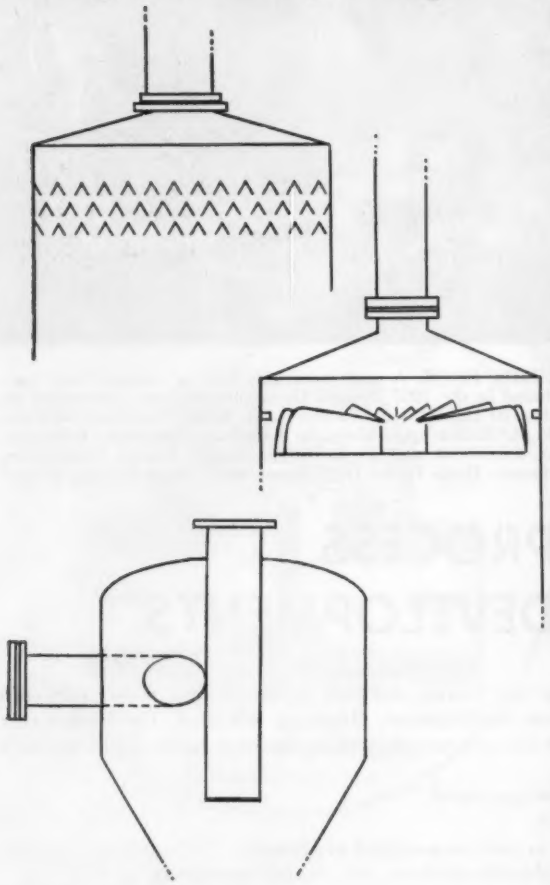
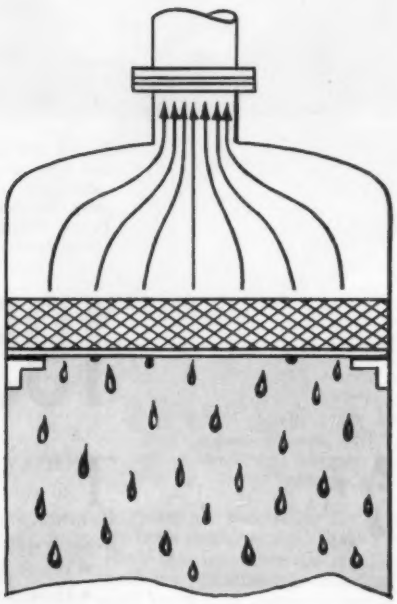


YORKMESH DEMISTERS are the Modern Way to do the Complete job of Mist Removal!



Why not take advantage of our vast experience in improving the performance of process equipment. In the past 10 years, the outstanding success of thousands of installations is proof of the superiority of YORKMESH DEMISTERS for entrainment control.

Yorkmesh Demisters are used to improve product quality, to avoid losses, and to increase thruput capacity. Our engineers will give careful consideration to the information you submit and will recommend the best answer to your problem. Write for our new bulletin #21.

YORKMESH DEMISTERS *improve the performance of:* **Vacuum Towers • Distillation Equipment • Gas Absorbers • Scrubbers • Evaporators • Knock-out Drums • Steam Drums**

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to obtain satisfactory hydrocracking reactions before. Now researchers show the process may be carried out at much lower pressures (below 1000 psi) provided a catalyst is used.

Coking is another method of converting residuals into gasoline and distillates (p. 211). Some refiners are finding this process more desirable than the common vis-breaking.

All of the processes of this type face a favorable economic situation. Residuals are the only major petroleum product selling for less than the original crude oil, and it is expected the relative demand and price of residuals will continue their present decline.

Reforming continues to furnish the lion's share of octane demand. The latest data on one of the more recently announced processes, Powerforming, is given in this issue (p. 221).

Although the aromatic products from reforming offer the best means of getting those top octanes, they exhibit very poor burning quality unless blended with paraffins. In the future much of these paraffins may be expected to come from alkylation.

Isobutane for alkylation may then be in a pinch. Some of the refiners now are making their own isobutane from the more plentiful normal butane. We present one of the several processes available for achieving this conversion (p. 223).

Reformates and alkylates for octane improvement have a drawback though—they are primarily C_7's and C_8's. The finished motor fuel must have high octane materials in the C_5 and C_6 range, too, if it is to have proper volatility.

Isomerization of pentanes and hexanes holds the most promise for satisfying this deficiency. The refiner has seven processes from which to choose. The latest of these, Iso-Kel, was announced at the beginning of this year. Some data on what may be expected from its products are reported in this issue (p. 215).

Product cleanliness also demands attention. The refiner gets his greatest benefit from treating by savings in processing. Hydrodesulfurization, for example, is used extensively on reformer charge to reduce the formation of corrosion products which plug expensive catalyst beds. One of the articles (p. 233) discusses the effects of hydrogen treating on a wide range of stocks. Another (p. 231) considers the removal of nitrogen base materials from a coker charge.

Lubes and waxes get their share of consideration. A new lube plant using furfural extraction is announced (p. 239). Oil-free wax can be made by a new spray process (p. 236).

The future holds many new changes for the industry. Even now the nuclear reactor is being examined as a refining tool (p. 243). Its use as a source of heat already has been studied extensively. Many refiners are installing radiation laboratories to see how gamma radiation will influence product foramtion.

These are the latest process trends in the refining industry. To ease the job of incorporating them into your refining scheme, see the primer on process design (p. 249), the group of articles on scale-up (p. 267), and the description of the work of engineer-contractors (p. 277).

The design primer suggests standards for flow diagrams, process calculations, and cost evaluations. The articles on scale-up tell what principle of similitude must be obeyed for various pieces of equipment. Then the report on engineer-constructors will give you insight into their function.

These are yours in the 1957 Process Developments Issue.

Harold Hoffman

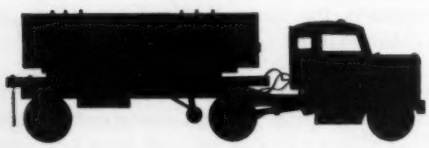
Process and Construction Editor

PROCESS BOXSCORE

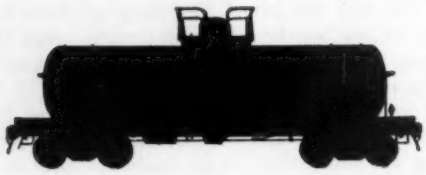
The activity in the refining industry to date may be seen in this tabulation of licensed process units operating and under construction.

Company and Processes	Units Operating	Units Under Construction
AMERICAN DEVELOPMENT CORPORATION		
Electrolytic Mercaptan	3	1
ATLANTIC REFINING COMPANY		
Catforming	20	7
BLAW-KNOX COMPANY		
Decarbonizing	1	0
THE BRITISH PETROLEUM CO., LTD.		
Autofining	3	0
CALIFORNIA RESEARCH CORPORATION		
California Polymerization	37	3
ESSO RESEARCH AND ENGINEERING COMPANY		
Fluid Catalytic Cracking (Mod. IV)	27	7
Fluid Hydroforming[1]	10	0
Fluid Coking	8	0
Hydrofining	29	45
Powerforming	11	22
FILTROL CORPORATION		
Continuous Contact Filtration	39	1
THE FLUOR CORPORATION, LTD.		
Glycol Amine Gas Treating	28	0
THE GIRDLER COMPANY		
Girbotol	400+	2
GULF OIL CORPORATION		
Polyforming	9	0
HOUDRY PROCESS CORPORATION		
Houdriflow (Including Houdresid)	20	1
Houdriforming (Including Iso-Plus)	15	6
Butane Dehydrogenation	6	3

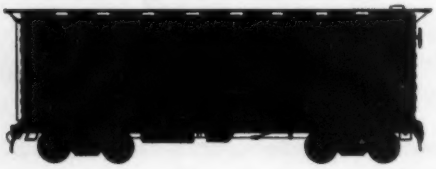
For FLUORINE gas or liquid



HYDROFLUORIC ACID aqueous or anhydrous



INORGANIC FLUORINE COMPOUNDS



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Hydrofluoric Acid, Anhydrous High Purity
Hydrofluoric Acid, Aqueous
Hydrofluoric Acid, Aqueous, Purified & Reagent
Hydrofluoric Acid, Electronic

ACID FLUORIDES
Ammonium Bifluoride
Potassium Bifluoride
Sodium Bifluoride

ALKALI FLUOBORATES
Ammonium Fluoborate
Potassium Fluoborate
Sodium Fluoborate

ALKALI FLUORIDES
Ammoninum Fluoride
Potassium Fluoride, Crystal & Anhydrous
Sodium Fluoride, Technical
Sodium Fluoride, Reagent

BORON FLUORIDE COMPLEXES
Boron Fluoride Ether (Diethyl) Complex
Boron Fluoride Phenol Complex
Boron Fluoride Diacetic Acid Complex
Boron Fluoride Di-n-Butyl Ether Complex
Boron Fluoride Dihydrate
Boron Fluoride Piperidine Complex
Boron Fluoride Ethyl "Cellosolve" Complex
Boron Fluoride Hexamethylene-tetramine Complex
Boron Fluoride Monoethylamine Complex
Boron Fluoride Para-cresol Complex
Boron Fluoride Triethanolamine Complex
Boron Fluoride Urea Complex

DOUBLE FLUORIDES
Chromium Potassium Fluoride
Potassium Ferric Fluoride
Potassium Nickel Fluoride
Potassium Titanium Fluoride
Potassium Zinc Fluoride
Potassium Zirconium Fluoride
Sodium Zirconium Fluoride
Sodium Silico Fluoride
Potassium Aluminum Fluoride

HALOGEN FLUORIDES
Bromine Trifluoride
Bromine Pentafluoride
Chlorine Trifluoride
Iodine Pentafluoride

METAL FLUORIDES
Aluminum Fluoride
Aluminum Fluoride, Crystal
Antimony Trifluoride
Antimony Pentafluoride
Barium Fluoride
Bismuth Trifluoride
Cadmium Fluoride
Calcium Fluoride
Chromium Fluoride
Cupric Fluoride
Lead Tetrafluoride
Magnesium Fluoride (Not Optical Grade)
Mercuric Fluoride
Manganese Trifluoride
Molybdenum Hexafluoride
Nickelous Fluoride
Selenium Hexafluoride
Silicon Tetrafluoride
Silver Difluoride
Stannous Fluoride
Strontium Fluoride
Titanium Tetrafluoride
Tellurium Hexafluoride
Tungsten Hexafluoride
Zirconium Tetrafluoride

NON-METALLIC FLUORIDES
Boron Fluoride, Gas
Sulfur Hexafluoride

METAL FLUOBORATE SOLUTIONS
Cadmium Fluoborate
Chromium Fluoborate
Cobalt Fluoborate
Copper Fluoborate
Ferrous (Iron) Fluoborate
Indium Fluoborate
Lead Fluoborate
Nickel Fluoborate
Silver Fluoborate
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PROCESS BOXSCORE . . . *Continued*

Company and Processes	Units Operating	Units Under Construction
HOWE-BAKER CORPORATION		
Electrical Desalting	101	8
Electrical Distillate Treating	19	31
HUSKY OIL COMPANY		
Diesulforming	2	1
THE M. W. KELLOGG COMPANY		
Catalytic Desulfurization	1	2
Fixed-Bed Hydroforming	8	0
Fluid Catalytic Cracking (Including Orthoflow)	66	1
Fluid Hydroforming	4	0
Polyco Catalytic Polymerization	29	6
Propane Deasphalting	42	0
Propane Decarbonizing	5	0
Propane Dewaxing	14	1
Propane Fractionation	4	0
S B K Catalytic Reforming	11	0
Sulfuric Acid Alkylation	26	2
THE LUMMUS COMPANY		
Combination Cracking	13	0
Continuous Contact Coking	1	0
MAGNOLIA PETROLEUM COMPANY		
Dualayer Fuel Oil Treatment	4	0
Dualayer Gasoline Treatment	2	1
THE MILWHITE COMPANY, INC.		
Duo-Sol	19	0
MINERALS & CHEMICALS CORPORATION OF AMERICA		
Continuous Percolation	0	1
PETRECO DIVISION, PETROLITE CORPORATION		
Electric Desalting	339	17
Electrofining	50	24
Petreco-Bender Sweetening	2	3
PHILLIPS PETROLEUM COMPANY		
Aluminum Chloride Alkylation	0	1
Catalytic Isomerization	0	1
Cycloversion	10	1
HF Alkylation	2	5
Isobutane Cracking	0	1
THE PURE OIL COMPANY		
Mercapsol Treating	2	0
SHELL DEVELOPMENT COMPANY		
Butane Vapor-Phase Isomerization	7	0
Trickle Hydrodesulfurization	3	2
Liquid-Phase Isomerization	5	0
Phosphate Desulfurizatioon	40	0
Two Stage Fluid Catalytic Cracking	1	0
Vapor-Phase Hydrodesulfurization	2	0
Solutizer Sweetening	34	0
SINCLAIR REFINING COMPANY		
Bender	6	3
Catalytic Reforming	27	1
SOCONY MOBIL OIL COMPANY, INC.		
Airlift TCC	47	3
Thermofor Catalytic Reforming	2	0
Thermofor Continuous Percolation	2	0
STANDARD OIL COMPANY (INDIANA)		
Ultraforming	17	7
STONE & WEBSTER ENGINEERING CORPORATION		
Crude Distillation for Maximum Cracking Feed	12	4
SO_2 Extraction	11	0
STRATFORD ENGINEERING CORPORATION		
Effluent Refrigeration Alkylation	8	7
Sulfuric Acid Alkylation	25	0
TEXACO DEVELOPMENT CORPORATION		
Furfural Extraction of Gas Oils	6	1
Furfural Refining	53	4
Solvent Dewaxing	74	1
Wax Fractionation	31	1
Wax Manufacturing	8	1
TRETOLITE COMPANY DIVISION		
Chemical Desalting	97	12
UNION OIL COMPANY OF CALIFORNIA		
Unifining	50	40

[1] Some processes are joint developments; therefore, the total number of units may be divided among several companies. Fluid Hydroforming, for example, is a joint development among The M. W. Kellogg Company, Standard Oil Company (Indiana), and Esso Research and Engineering Company and is available through several engineering contracting companies.

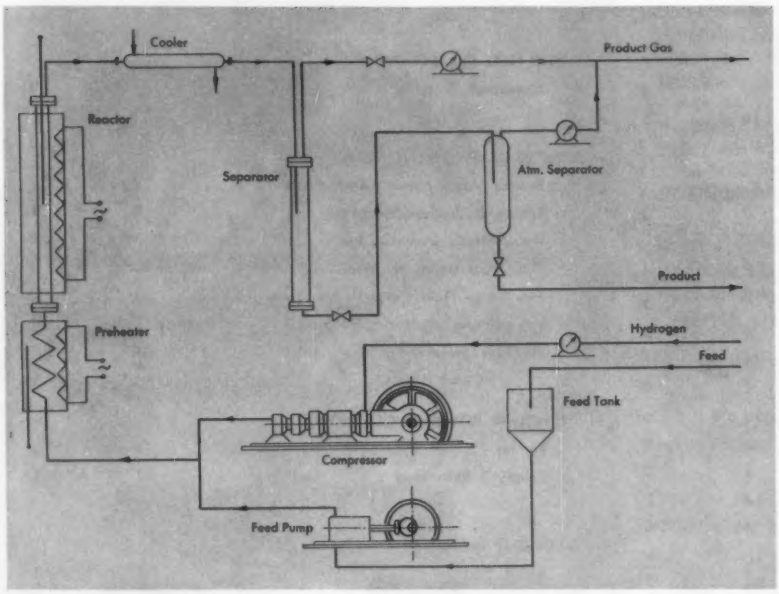

FIGURE 1—The distillate which is used as a diluent may originate from the crude itself.

Now You Can Hydrocrack Those Asphaltic Crudes

These data show how asphaltic crudes may be up-graded by cracking in the presence of hydrogen and a catalyst.

J. Varga, J. Károlyi, Gy. Rabó, P. Steingaszner, A. Székely, and A. Zalai
Nogynyomásu Kisérleti Interzét
Budapest, Hungary

HEAVY CRUDES of high asphalt and sulfur content are going to demand a more and more increasing share in world oil production. In Hungary too, in the Transdanubian district, a crude oil of this type was discovered in 1951. The oil contains about 3 weight percent of sulfur and 15 weight percent asphaltene insoluble in n-hexane. The crude yields by straight run distillation about 4 volume percent gasoline of low octane number as well as a gas oil of 16-18 volume percent of good cetane number, both containing, however, more sulfur than allowed by standards. The vacuum distillation of the atmospheric residue yields further 30 volume percent of vacuum gas oil and 50 weight percent vacuum residue. The latter can be processed to asphaltic bitumen of high quality by blowing. Quantity and quality of motor fuels obtained from the oil by the usual crude oil refining technology did not, however, meet requirements and therefore, it became essential to work out a method to increase considerably the yield of motor fuels from that crude oil.

Several processes are known for the increase of the yield of motor fuels. No doubt, best yields may be obtained by the high pressure hydrogenation as developed in Germany. However, hydrogenation of high asphalt crudes must be performed at a pressure of 10,000 psia.[1]

Due to the considerable hydrogen consumption, and to the high investing expenses, the high pressure hydrogenation seems not to be attractive economically for the time being.

These heavy crudes can be cracked by different thermal processes. The yields when cracking the heavy Transdanubian crude in the nonresiduum process, are 59 volume percent of gasoline (0.5 percent sulfur and 59 F-2 octane number) and very much, about 30 weight percent of coke. When cracking to fuel oil, only 41 volume percent of gasoline (0.35-0.55 percent sulfur and 56 F-2 octane number) and 50 volume percent of fuel oil of high viscosity (8-80 E at 100 C), are being formed.[2] By way of delayed coking too, considerable amount of coke, about 25 weight percent, but 75 volume percent of gasoline and gas oil can be produced.[3] A well-known advantage of thermal processes is that they can be carried out in plants requiring relatively low investment costs, but the amount of motor fuels produced by these processes is smaller than that resulting from high-pressure hydrogenation.

With regard to these facts, it seemed to be advisable to elaborate a process combining the advantage of both the high pressure hydrogenation and of the cracking processes.

In order to achieve this, reaction conditions of the two-kinds of technology, often contradictory, had to be brought to accord to fulfill the following requirements:

- Lower pressure than that used in the hydrogenation industry.

- The least hydrogen consumption possible.
- Efficient selective cracking of the asphaltenes and heavy oils with the least coke and gas formation possible.

In the course of our work it was tried first to hydrogenate the heavy crude oil in the presence of tetralin and hydrogen by means of hydrogen transfer reaction. At a pressure of 1000 psia satisfactory results have been obtained.[4]

Further research proved that the middle pressure hydrogenation of the heavy crude was rendered possible also when substituting tetralin partly or totally by light and/or middle oil distillates.

Description of Process. Chief feature of the new process is that high asphalt crudes in admixture with a sufficient amount of diluent, can be cracked continuously at relatively low pressures in the presence of hydrogen and suspended catalyst.

The diluent distillates may originate from the crude itself, or from outside sources, but a corresponding fraction of the hydro-cracked product may also be used. The catalyst is applied in a finely pulverized form; for most feed stocks a catalyst made of brown-coal semi-coke may be used.

Operating conditions. The process can be carried out at *temperatures* of 750-900 F. Reaction temperature depends on the quality of the raw material and on the degree of the hydrocracking required; with the majority of feedstocks this temperature lies between 790-840 F.

Pressure interval most tested in the course of this research work was from 450 to 1500 psia, however, most raw materials can be hydrocracked at pressures of 750-1000 psia.

The severity of hydrocracking may be influenced also by the *space velocity.* The examined velocity limits are 40 and 240 pounds per cubic foot per hour; in general, space velocities of 80-160 lb./cu. ft/hr are preferred.

As hydrogenating gas, pure hydrogen or gases rich in hydrogen, e.g.: reformer gas, coke oven gas, etc., may be used at a *gas circulation* rate of 6-26 cubic feet per pound of feed.

Laboratory Experiments. The initial experimental work was carried out in the continuously operated apparatus shown in Figure 1. This consisted of an electrically heated preheater, an electrically heated reactor with a volume of 2 lt., a cooler and gas-liquid separators as well as a compressor, feed pumps and suitable measuring and controlling equipment.

The required hydrogen was drawn from a near-by ammonia plant, in the form of a synthesis gas of 73-75 percent by volume hydrogen content.

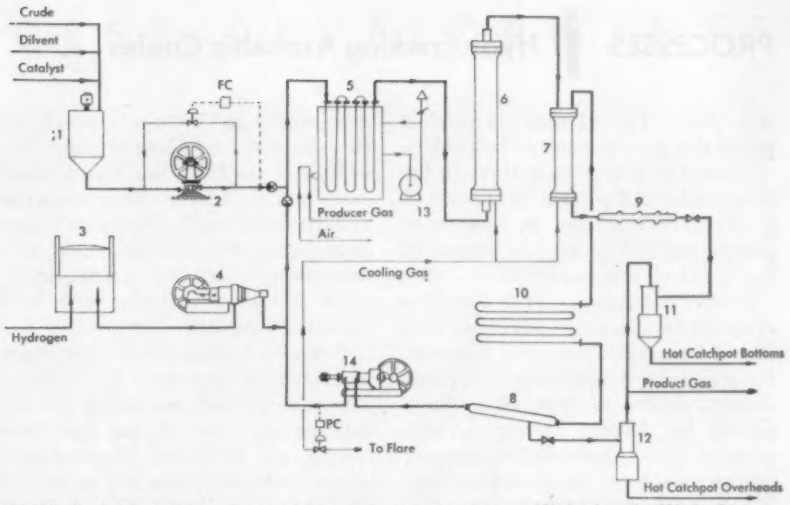

FIGURE 2—In the pilot plant set-up, the main components are: (1) feed tank, (2) feed pump, (3) gas holder, (4) hydrogen compressor, (5) preheater, (6) reactor, (7) hot catchpot, (8) cold catchpot, (9) heavy oil cooler, (10) light oil cooler, (11) heavy oil flash drum, (12) light oil flash drum, (13) flue gas ventilator, (14) gas circulating compressor, (PC) pressure controller, and (FC) flow controller.

TABLE 1
Properties of Transdanubia Heavy Crude

Specific gravity at 25 C	0.947 g/ml
Sulfur, wt %	3.2 wt %
Conradson residue	14.3 wt %
Water	1.7 wt %
Product Distribution and Properties of the Cuts	
Gasoline/cut.point 190 C	4.4 Vol.%
Specific gravity at 25 C	0.730 g/ml
Sulfur	0.1 wt %
Octane Number, F-2 clear	about 30
Gas Oil/190 C. to 380 C	17.8 Vol. %
Specific Gravity at 25 C	0.872 g/ml
Sulfur	1.8 wt %
Conradson residue	0.1 wt %
Cetane number, calculated	about 60
Heavy Gas Oil/380 C. to 500 C	30.3 Vol. %
Specific gravity at 25 C	0.933 g/ml
Sulfur	2.7 wt %
Conradson residue	0.5 wt %
Vacuum residue/500 C. and heavier	51.5 wt %
Specific gravity at 25 C	1.050 g/ml
Sulfur	4.1 wt %
Conradson residue	30.8 wt %
R & B softening point	60-80 C.

TABLE 2
Properties of Transdanubia Long Gas Oil Distillate

Specific gravity at 25 C	0.849 g/ml
Sulfur	1.2 wt %
Conradson Residue	0.3 wt %
ASTM distillation, °F.	
First drop	327
5 Vol. %	376
10 Vol. %	420
30 Vol. %	511
50 Vol. %	601
70 Vol. %	678

TABLE 3
Results of Hydrocracking of Heavy Transdanubia Crude

Reaction Conditions	Straight Run Distillation	Laboratory Run	Pilot Plant Run
Temperature, °F	—	825	810
Pressure, psia	—	1000	1300
Space velocity lb./cu. ft./hr.	—	80	80
Gas circulation rate cu. ft./lb. feed	—	26	20
Product distribution related to original crude			
Gas, wt %	—	4.8	6.2
Gasoline, Vol. %	4.4	9.8	14.9
Gas Oil, Vol. %	17.8	68.2	62.9
Heavy Gas Oil, Vol. %	30.3	12.0	9.4
Vacuum Residue, wt %	51.5	20.5*	21.5*
Hydrogen Consumption, wt %	—	1.7	0.7

* Including spent catalyst.

TABLE 4
Properties of Hydrocracked Transdanubia Crude Product Fractions

Gasoline/cut point 190 C.	
Specific gravity at 25 C	0.756 g/ml
Sulfur	0.19 wt %
Octane No. F-2 clear	44
F-2 + 2.85 ml TEL per gal.	64
Gas oil/cut point 380 C.	
Specific gravity at 25 C	0.848 g/m
Sulfur	1.03 wt %
Conradson residue	0.03 wt %
Cetane No./calculated/	55
Heavy gas oil/cut point 500 C.	
Specific gravity at 25 C	0.929 g/m
Sulfur	2.2 wt %
Conradson residue	0.10 wt %
Vacuum residue/above 500 C.	
Specific gravity at 25 C	1.1 g/ml
Sulfur	4.0 wt %
R & B softening point	80/100 C.

Processing of High Asphalt Crudes. The Transdanubian crude of high asphalt content as described in Table 1, was mixed with an oil distillate gained from the same oil in proportion of 1 to 1 (see Table 2). Reaction conditions of hydrocracking as well as yield data are summarized in Table 3. For comparison product distribution data as obtained by straight run distillation of the same crude, are

also given. Typical data on product properties are summarized in Table 4.

From the heavy crude through hydrocracking 9.8 percent by volume of gasoline, 68.2 percent by volume of gas oil and 12.0 percent by volume of heavy gas oil was produced.

Hydrocracking of Transdanubian crude yields more fuel distillates than thermal cracking processes, however, the quality of the products is in many respects similar to those of products gained by delayed coking or high pressure mud-phase hydrogenation: octane number of the gasoline is low, its sulfur content is high. Before utilizing it for automotive purpose, its octane number has to be increased through some reforming process. The product gas oil is of a very good cetane number, however, in general, its sulfur content exceeds the permissible value.

By means of medium pressure hydro-desulphurization practically sulfur-free gasoline and gas oil can be obtained.

According to requirements, lighter distillates too can be gained out of the desulfurized middle oils by way of cracking.

The vacuum residue containing the spent catalyst amounts to 20.5 weight percent of the heavy crude. This residue of high melting point is exceedingly suitable, e.g.: to promote coking of non-baking coals or as briquetting agent.

Pilot Plant Experiments. In order to establish more correct design data, a pilot plant having a capacity of 10 metric tons per day, has been built. The flow-sheet of the plant is shown in Figure 2. The plant consists of a four-part convection heater, a reactor of about 400 lt. reaction space, a hot oil catchpot, a cooling system and cold catchpots. As hydrogenating gas ammonia-synthesis gas has been used containing 73-75 percent by volume hydrogen. The gas has been compressed to reaction pressure by an electrically driven four-stage high pressure compressor. The hydrogen rich gas has been circulated in the system by means of gas circulating compressors. The crude oil has been mixed with diluent and with the catalyst in vessels of conical bottom. This mixture was fed into the system by an electrically driven plunger-pump. The volume of the high- and low-pressure gases and liquids has been measured and recorded with ring-balance type instruments. Pressure and feed rate have been controlled automatically, while the other variables have been regulated manually.

Products leaving the reactor, separate into a gaseous and a liquid phase. The gaseous part consists of the circulating gas and of the light and middle oil distillates noncondensed under conditions prevailing in the hot catchpot. The liquid part, bulk of which is heavy oil, contains the spent catalyst together with the coke formed in the course of the process.

Technological conditions prevailing during the pilot plant experiments, and yield data are summarized in the 3rd column of Table 3.

Results. From data of Table 3, it is evident that results obtained from the run carried out in the pilot plant, correspond with those of the laboratory experiments. Product distribution within the limits of experimental error is the same as in case of the laboratory experiment. Pilot plant products were of qualities similar to those of the products of the laboratory run.

The pilot plant has been operated for several weeks without any technical breakdown. This proved the technical feasibility of the process.

The hydrocracking process renders possible the processing of high asphalt crudes. By way of the process feed stocks of otherwise unfavorable quality and product distribution, can be transformed into motor fuels more efficiently and under circumstances in many respects more favorable than by other known processes. Results of industrial-scale runs and economics of the process will be reported in a later publication.

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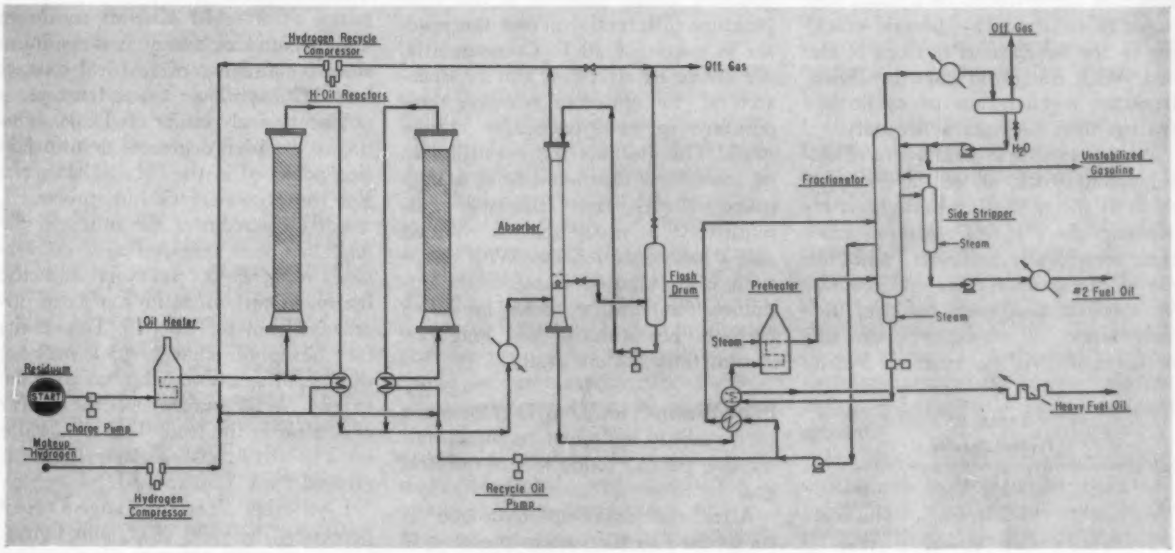

FIGURE 1—If inadequate hydrogen is available from reformers, the hydrogen demand for this process may be obtained from partial oxidation.

This New Process Handles Residuals

Here is the announcement of a new process called "H-Oil" process. See how it hydrogenates heavy residual stocks into useful products.

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M. Chervenak, C. A. Johnson, M. C. Sze and J. F. Campagnolo, Hydrocarbon Research, Inc., New York

HYDROCARBON RESEARCH, INC., developed recently a new process at its Trenton, New Jersey, Laboratories called the "H-Oil" process. This process has the ability to reduce refinery heavy residual stocks to the plant fuel requirement and converts the remainder into valuable distillate products. In addition, by adjusting operating conditions this process has the flexibility to produce varying quantities of each distillate product depending on changes in demand, seasonal or otherwise.

Before this process could be offered to treat a wide range of stocks it was necessary to solve the many problems that have always confronted investigators in the field of hydrogen-treating of heavy residues. One problem was, of course, the availability of cheap hydrogen for hydrogenation use.

In many refineries today, adequate cheap hydrogen is available from catalytic reforming operations. Other refineries, however, must produce, in part or in whole, their hydrogen requirements, if hydrogenation processing is to be adopted. With the recent commercial success of the partial oxidation process as licensed by Texaco Development Company and Hydrocarbon Research, Inc., the tool to produce hydrogen from all types of refinery distressed stocks becomes available. The supply of hydrogen thus constitutes no problem.

Other problems which had to be solved were mainly related to the hydrogenation or "H-Oil" reactor, which is the heart of the process. In the development of the "H-Oil" process, it is recognized that the following requirements must be achieved. The reactor must give efficient contact of hydrogen and liquid hydrocarbons at low pressure drop. In treating heavy residues, metal salts in the residue must not affect the catalyst performance. The same reactor must be capable of remaining onstream continuously for long periods of time even when treating heavy residues, so that no expensive short-period cyclic regeneration operation is necessary.

This last condition is a difficult one to attain, especially when deep hydrogenation is attempted. Since the hydrogenation reaction is highly exothermic, there must be positive and efficient control of temperature throughout the catalyst bed. Unless controlled, the heat liberated in deep hydrogenation can raise the temperature of the reactants several hundred degrees Fahrenheit. In such a catalyst bed only a small fraction of the bed would be at optimum tempera-

ture and there would be a rapid lay-down of coke due to thermal cracking in the overheated sections of the bed. With the rapid coke lay-down, frequent regeneration or cyclic operation then becomes a necessity.

As a result of several years of development work, all of the goals set forth in the preceding paragraph regarding the "H-Oil" reactor have been successfully achieved. With the use of the specially designed reactor, the catalyst bed, even for deep hydrogenation, is operated essentially isothermally. At no time in hydrogenating heavy residues is the temperature differential across the reactor in excess of 20 F. Consequently, the entire catalyst bed can be operated at the optimum reaction temperature for the particular charge stock. This permits the operation to be conducted continuously at a high space velocity, thus requiring comparatively a small reactor volume and a less costly reactor. With essentially isothermal operation at the optimum temperature, coke lay-down becomes no problem and long on-stream time is thus attained.

TABLE 1
Typical Results

	Kuwait Residuum	Furfural Extract Plus TCC Synthetic Tower Bottoms
Charge:		
Gravity, °API	8.3	9.1
Sulfur, Wt. %	5.32	1.39
Ramsbottom Carbon, Wt. %	17.2	1.29
Hydrogen Consumption:		
SCF/Bbl. of Charge	1500	2050
Product Fractions:		
C_4's Yield, Vol. %	2.5	2.7
Gasoline (C_5-380°)		
Yield, Vol. %	19.8	24.3
Gravity, °API	53.5	52.6
Sulfur, Wt. %	0.057	<0.01
Aniline Point, °F	130	127
Bromine Number	2.0	0.6
No. 2 Distillate Fuel Oil (380°-650°):		
Yield, Vol. %	24.0	42.4
Gravity, °API	34.7	32.4
Sulfur, Wt. %	0.17	0.02
Aniline Point, °F	136	133
Bromine Number	5.0	3.9
Heavy Gas Oil:		
Boiling Range, °F	650-975	650-850
Yield, Vol. %	29.1	31.2
Gravity, °API	21.7	.....
Sulfur, Wt. %	0.64	0.08
Residue:		
Boiling Range, °F	975F +	850 F +
Yield, Vol. %	29.4	4.2
Gravity, °API	9.1	.....
Sulfur, Wt. %	2.52	.....

TABLE 2
Effect of Catalyst Age on Its Activity

Charge Stock	8 °API Kuwait Residuum	
Hours on Stream	370	1170
Product Yields:		
C_1-C_3, Wt. %	2.5	3.3
C_4-400° F, Vol. %	14.8	15.7
400°-650° F, Vol. %	18.6	21.0
650°-975° F, Vol. %	43.4	35.2
975° F+, Vol. %	27.1	31.0
C_4+ Liquids, Vol. %	103.9	102.9
Conversion (100-Vol. % 975° F+)	72.9	69.0
Inspections on Fractions:		
IBP—400° F.:		
Gravity, °API	56.8	56.9
Sulfur, Wt. %	Negligible	Negligible
400—650° F:		
Gravity, °API	34.7	35.1
Sulfur, Wt. %	0.097	0.14
650—975° F:		
Gravity, °API	21.0	20.6
Sulfur, Wt. %	0.75	1.07
975° +:		
Gravity, °API	8.2	5.5
Sulfur	2.50	3.47

Pilot Plant. The 25 B/D pilot plant used makeup hydrogen manufactured by the partial oxidation of natural gas.

After the make-up hydrogen is compressed to the system pressure, it joins the recycle hydrogen and the stream is preheated. Hot heavy residue charge stock is pumped also to the system pressure and preheated. The total hydrogen and oil feeds then enter the "H-Oil" reactor.

In the reactor, the feed oil is contacted with hydrogen in the presence of a standard commercial desulfurization catalyst and undergoes hydrodesulfurization, hydrogenation and some hydrocracking reactions. The net effect of these reactions is to yield a high conversion of the residual material to lighter distillates of high quality, especially with regard to sulfur, nitrogen and oxygen contents.

The reactor effluent is cooled and the condensed oil is separated from the hydrogen in a separator. Before it is recycled, the hydrogen from the separator is scrubbed with oil to remove some inert constituents. High pressure liquid is let-down to atmospheric pressure and the gas and liquid products are collected and analyzed.

The following stocks which have been processed indicate the variety which can be handled in the "H-Oil" unit: catalytic cracker cycle oil, fluid catalytic cracker decanted oil, vacuum Kuwait residue, Mid-Continent residue, furfural extract and propane deasphalter tar. When running on an 8° API heavy Kuwait residue, the large pilot plant reactor stayed on stream continuously for over 1200 hours followed by voluntary shutdown.

Typical Results. Examples of the versatility of the "H-Oil" Process can be noted from the results shown in Table 1. These data are for the processing of 8° API Kuwait residuum and a blend of heavy non-residuum stocks, consisting of furfural extract and TCC synthetic tower bottoms.

The typical results of Table 1 indicate the high degree of desulfurization achieved in the "H-Oil" Process. For the Kuwait residuum processed, about 80 percent of the sulfur in the feed has been removed at a conversion level of 71 percent and the hydrogen-carbon ratio has been increased from 1.47 to 1.79. The results for the lighter charge stock indicate that desulfurization achieved is to the extent of 98 percent of the sulfur occurring in the feed. The H/C ratio for this stock has similarly been increased from 1.50 to 1.91.

Like other deep hydrogenation processes, the yield of C_4 plus liquids is in excess of 100 volume percent, generally about 103 to 105 percent. The products obtained are of superior quality. The heavy gas oil is low in sulfur and high in H/C ratio. It is a choice catalytic cracking charge. The No. 2 distillate or Diesel cut is a low sulfur high stability marketable product. The gasoline has low sulfur but requires reforming to improve its octane to the usual refinery pool octane level.

Selective Hydrogenation. In the course of developing this process, it soon became evident that the heavy gas oil fraction produced in the processing of heavy residuums can be advantageously recycled to a second reactor operating under slightly different conditions to yield directly high grade No. 1 or No. 2 distillates. Other refinery distress distillate stocks, such as furfural extract, may also be charged to the same second reactor. Experimental investigation has since demonstrated the practicability of such a two reactor system. A more detailed description of such a flowsheet is given later.

Process Variables. The following process variables have been investigated in the laboratory development work:

Temperature—The severity or degree of hydrogenation can be controlled by adjusting the temperature of the catalyst bed. Depending upon the charge stock and the anticipated

results, the optimum temperature ranges from 700 F to 875 F. It should be emphasized here again that in the "H-Oil" reactor, the temperature spread across the catalyst bed is easily and cheaply maintained at no greater than 20 F irrespective of the degree of hydrogenation achieved or the amount of heat of reaction liberated. This is the result of the special reactor design.

Space Velocity—Space velocity is defined as the volumes of oil flow per hour per volume of catalyst. The severity of the operation can be varied by adjustment of space velocity, the higher the space velocity the lower the severity. Hence, temperature and space velocity can be varied independently for optimum processing of a particular stock. Usually for treating lighter distillates, a space velocity of 5.0 or more can be used. For processing heavy residues continuously, a space velocity of 1.0 is more desirable.

Pressure—Generally, the heavier charge stocks require higher pressures to obtain high desulfurization and high yields of light distillates. For treating light distillates, lower pressures are entirely satisfactory. Pressures in the range of 500 to 3000 psig have been investigated.

Coke Laydown—When heavy residuums are processed, it has been found that there is a slight coke laydown on the catalyst in the "H-Oil" reactor. But due to the excellent temperature control, the rate is very slow and a long continuous run can easily be counted on. The ability to maintain catalyst activity can be shown by data given in Table 2 which compares the results obtained at two periods of the same continuous run. It can be seen that the activity after 1170 hours is only slightly under that after 370 hours.

Hydrogen Consumption—Hydrogen consumption is a function of the type of stock processed and severity of operation. For stabilization of middle distillates with some desulfurization, the hydrogen consumption can be limited to 100 to 200 scf per barrel of feed oil. In several operations with high sulfur residuums and at conversions in the order of 75 percent, the hydrogen consumption will be from 1000 to 1400 scf per barrel of feed oil.

When treating materials of low H/C ratio and high sulfur contents, hydrogen consumption of 1800 scf or more per barrel has been experienced.

Purity of Hydrogen Feed Stream—Except for fairly large concentrations of carbon monoxide, the impurities normally present in hydrogen-rich streams, such as nitrogen and light hydrocarbons, do not have any adverse effect either on the catalyst or to the process. It is, of course, evident that if these inerts were permitted to build up to high concentrations, the effective hydrogen partial pressure would be reduced and it would be necessary to raise the system pressure to offset this effect.

Economic Studies. It is possible to make economic evaluations for a number of processing schemes depending on the particular refiner's needs. While the studies presented here are concerned primarily with processing of residual stocks, this in no way implies that other stocks cannot be economically treated. For example, the process can be used to treat advantageously high sulfur whole crudes, not only for desulfurization, but also to increase the yield of lighter distillate fractions.

Two economic studies have been worked out for "H-Oil" plants processing residual stocks. These plants have been designed for throughputs of 14,000 bpsd and 5000 bpsd. A simplified flowsheet for the oil processing is schematically shown in Figure 1.

Heavy residuum is pumped to the system pressure, preheated in a fired heater and charged to one of two "H-Oil" reactors. Also fed to this reactor is the required hydrogen stream. Make-up hydrogen, after it is compressed to the system pressure, is mixed with recycle hydrogen. The required amount of this mixed hydrogen stream is preheated by heat exchange against the reactor effluent before joining the heavy residual charge.

In this "H-Oil" reactor, highly exothermic hydrogenation reaction takes place. Leaving the reactor, the effluent is cooled first by heat exchange against incoming hydrogen and then by cooling water to ambient temperature. The vapor and liquid mixture, together with those from the other "H-Oil" reactors, flows to a separator, from which the liquid product is withdrawn through a let-down valve. The recycle hydrogen stream from the separator is scrubbed with lean oil to increase its

TABLE 3

Basis: Complete H-Oil Plant, H_2 Mfg. Plant, Products Recovery & MEA Off-Gas Purification Unit
Plant Investment..... $11,200,000
Capacity..... 14,000 BPSD
Stream Efficiency..... 90%

	Unit	Daily Quantity	Unit Cost	Daily Cost	Cost/Daily Bbl.
1. Oil Charge					
Feed (H-Oil Unit)	Bbl.	14,000	$1.50	$21,000.00	$ 1.500
Feed (H_2 Plant)	Bbl.	1,800	1.50	2,700.00	0.193
	.....	.....	....	23,700.00	1.693
2. Materials					
"H-Oil" Catalyst	Lbs.	1,165	0.95	1,106.75	0.0792
MEA	Lbs.	15	1.30	4.50	0.0003
H_2 Plant Chemicals				48.00	0.0034
H_2 Plant Shift Catalyst	Lbs.	150	0.60	90.00	0.0064
Lube Oil	Gals.	42	1.00	42.00	0.0030
	.....	.....	....	1,291.25	0.0923
3. Utilities					
Condensate	M Gals.	41	0.20	8.20	0.0006
Cooling Water	M Gals.	21,450	0.02	429.00	0.0307
Steam 400 psig, 550 F	M Lbs.	2,055	0.42	863.10	0.0616
Steam 150 psig, Sat.	M Lbs.	602	0.40	240.80	0.0172
Steam 50 psig, Sat.	M Lbs.	96	0.35	33.60	0.0024
Power	KWH	33,600	0.008	268.80	0.0192
	.....	.....	....	1,843.50	0.1317
Credit for Off-Gas (970 BTU/SCF)	MSCF	2,800	0.30	—840.00	—0.0600
	.....	.....	....	1,003.50	0.0717
4. Labor	Man-Hr.	216	2.75*	594.00	0.0424
5. Supervision @ 35% Direct Labor	.....	.....	....	207.90	0.0148
Total Labor	.....	.....	....	801.90	0.0572
6. Maintenance @ 3%/Yr. of Investment	.....	.....	....	1,020.00	0.0728
7. Taxes and Insurance @ 2%/Yr. of Investment	.....	.....	....	680.00	0.0486
Total Costs before Depreciation	.....	.....	....	28,496.65	2.035
8. Depreciation @ 10%/Yr. of Investment	.....	.....	....	3,400.00	0.243
All Costs—Total	.....	.....	....	31,896.65	2.278

* Including Fringe Benefits, etc.

concentration. The purified recycle hydrogen is then recycled by a booster compressor. The rich oil from the scrubber is let down in pressure in a flash drum, releasing the absorbed constituents and is then pumped back to the top of the absorber.

The product liquid flows from the separator through exchangers where it is preheated and then through a furnace where, with the aid of steam injection, the desired degree of vaporization is accomplished before the oil enters the fractionator. The fractionator separates the "H-Oil" product into gasoline, No. 2 distillate fuel oil, heavy gas oil and residuum fuel oil. The residuum oil exchanges heat against fractionator feed and is cooled in a box-type cooler before going to storage. A portion of the heavy gas oil sidestream gives up heat to the tower feed, while the remainder is recycled to the other "H-Oil" reactor. Any distress refinery distillate stocks such as catalytic cracker cycle stock may also be charged to this second reactor. The second reactor system is similar to the first except in operating conditions.

TABLE 4—Payout for 14,000 BPSD Plant

	Vol. % on Charge to "H-Oil" Unit	BPSD	Unit Price	Daily Income
Income from Products Obtained:				
C_4 Plus Gasoline	33.8	4,730	$4.20/Bbl.	$ 19,850
No. 2 Fuel Oil	45.4	6,350	$4.20/Bbl.	26,650
Heavy Fuel	26.5	3,710	$1.50/Bbl.	5,565
	105.7	14,790	.....	52,065
Daily Costs (including charge stock but excluding depreciation and royalty)	....	....	.....	28,497
Profit before depreciation—Daily	....	....	.....	23,568
Profit before depreciation—Yearly	....	....	.....	7,778,000
Payout Time	....	....	.....	1.4 Years

TABLE 5

Basis: H-Oil Plant with MEA Off-Gas Purification Unit, Products Recovery and H_2 Compression
Plant Investment $4,200,000
Capacity ..... 5,000 BPSD
Stream Efficiency 90%

	Unit	Daily Quantity	Unit Cost	Daily Cost	Cost/Daily Bbl.
1. Feed					
Oil	Bbl.	5,000	$1.50	$ 7,500.00	$ 1.500
Cat. Reformer H_2	MSCF	10,000	0.11	1,100.00	0.220
	.....	.....	....	8,600.00	1.720
2. Materials					
"H-Oil" Catalyst	Lbs.	416	0.95	395.20	0.0792
MEA	Lbs.	5	0.30	1.50	0.0003
Lube Oil	Gals.	14	1.00	14.00	0.0028
	.....	.....	....	410.70	0.0823
3. Utilities					
Cooling Water	M Gals.	4,450	0.013	57.80	0.0116
Steam 150 psig, Sat.	M Lbs.	275	0.40	110.00	0.0220
Steam 50 psig, Sat.	M Lbs.	35	0.35	12.25	0.0025
Power	KWH	8,950	0.008	71.60	0.0143
	.....	.....	....	251.65	0.0504
Credit for Off-Gas (970 BTU/SCF)	MSCF	1,430	0.30	429.00	0.0858
Steam, 400 psig, Sat. Produced	M Lbs.	165	0.40	66.00	0.0132
Total Credit	.....	.....	....	495.00	0.0990
Net Utility Credit	.....	.....	....	243.35	0.0485
4. Labor	Man-Hr.	96	2.75*	264.00	0.0528
5. Supervision @ 35% of Direct Labor	.....	.....	....	92.40	0.0185
Total Labor	.....	.....	....	356.40	0.713
6. Maintenance @ 3%/Yr. of Investment	.....	.....	....	382.00	0.0765
7. Taxes and Insurance @ 2%/Yr.	.....	.....	....	254.66	0.0510
Total Costs before Depreciation	.....	.....	....	9,760.41	1.953
8. Depreciation @ 10%/Yr.	.....	.....	....	1,275.00	0.255
Total	.....	.....	....	11,035.41	2.208

* Includes Fringe Benefits, etc.

TABLE 6—Payout for 5000 BPSD Plant

	Vol. % on Charge to "H-Oil" Unit	BPSD	Unit Price	Daily Income
Income from Products Obtained:				
C_4 Plus Gasoline	33.8	1,690	$4.20/Bbl.	$ 7,100
No. 2 Fuel Oil	45.4	2,270	$4.20/Bbl.	9,540
Heavy Fuel	26.5	1,320	$1.50/Bbl.	1,980
	105.7	5,280	.....	18,620
Daily Costs (including charge stock but excluding depreciation and royalty)	....	....	.....	9,760
Profit before depreciation—Daily	....	....	.....	8,860
Profit before depreciation—Yearly	....	....	.....	2,924,000
Payout Time	....	....	.....	1.4 years

For the 14,000 B/SD unit considered, it is assumed that the unit must supply its entire hydrogen requirement by a hydrogen plant using the partial oxidation process. It further includes a monoethanolamine scrubbing unit for purification of the off-gas of H_2S. Part of the off-gas is used to drive gas-engine driven compressors and to fire the process heaters.

For the 5000 B/SD unit, it is assumed that byproduct hydrogen from a catalytic reformer is available at the refinery and no hydrogen manufacturing facilities are included.

In Tables 3 and 4, the economics for the 14,000 bpsd complete "H-Oil" plant is presented. The pay-out time as calculated is about 1.4 years, which must be considered attractive. Similarly Tables 5 and 6 present the economics for the smaller 5000 bpsd "H-Oil" plant. Due to the fact that byproduct hydrogen is available, a similarly attractive pay-out time is obtained. Another interesting result to note is the low out-of-pocket processing cost. From Tables 3 and 5, the out-of-pocket processing cost excluding charge stock is approximately 35 cents per barrel of oil charged to the "H-Oil" unit.

Applications. While only the hydrogenation of heavy residues is presented in this paper, it should be mentioned that the "H-Oil" process is a very flexible one. It may be used to desulfurize or stabilize light distillates. It may also be used to improve diesel index or cetane number of cracked middle distillates. If a refinery plans to run a high sulfur crude oil, the "H-Oil" process may be used with advantage to desulfurize and hydrogenate the whole crude prior to topping or other refining operations.

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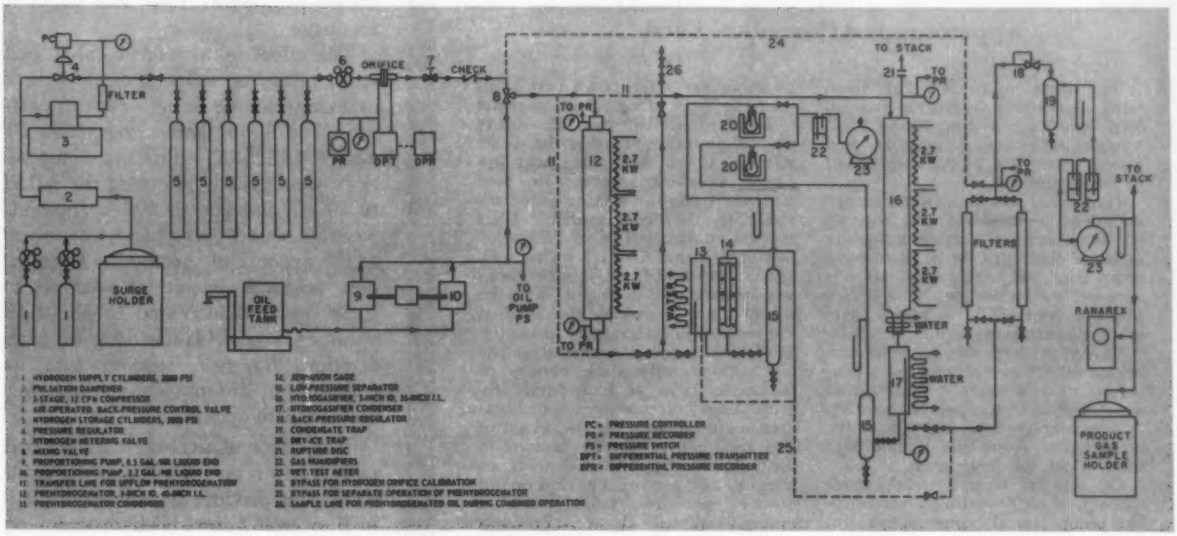

This is the apparatus which was used. The procedure for operation is described on following page.

Hydrocrack and Gasify To Upgrade Stocks

Hydrocracking may be used to produce aromatics for motor fuel blending and a stock suitable for subsequent hydrogasification. Here are some data on these two processes.

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Chicago

THIS STUDY OF hydrocracking and hydrogasification at 1500 psig indicates the feasibility of continuous conversion of distillate oils, and of catalytically prehydrogenated residual oils, to high-methane-content fuel gases and smaller amounts of liquid products consisting primarily of aromatics in the gasoline boiling range.

Conversion rates decrease with increases in feedstock aromaticity, but carbon-forming tendencies of residual oils can be satisfactorily controlled by hydrocracking over commercial cobalt molybdate catalysts at 850 to 900 F. The relative quantities of gaseous and liquid products, and the product compositions, do not seem to be greatly affected by feedstock properties as long as essentially complete elimination of the Conradson carbon residue of residual oil is accomplished in the catalytic hydrocracking pretreatment step.

Low-grade asphaltic crude oils, shale oils or fluxed gilsonite may be converted to high-Btu fuel gas and light aromatics, and the gas transmitted to urban areas in existing natural gas pipelines. Hydrogen requirements for this process, discussed in a previous paper,[22] could be met by pressure reforming of approximately one-third of the product gas.

In the experimental results, product distributions, compositions and rates of production are compared for operation at the same pressure (1500 psig) and hydrogasifier temperature (about 1400 F) for all feeds, with feed rates, hydrogen/oil feed ratios and hydrocracking temperatures adjusted in each case to produce comparable fuel gases of about 900 Btu/SCF and 70 mole percent methane content. Comparisons of operation with diesel oil, reduced crude and Bunker "C" fuel oil are drawn from runs of up to 20 hours duration.

Hydrocracking of Residual Oils

A 7.04 C/H weight ratio reduced crude petroleum oil and an 8.51 C/H weight ratio Bunker "C" fuel oil were hydrocracked over commercial cobalt molybdate catalysts at 1500 psig, 830 to 905 F, 9500 to 14,000 SCF of hydrogen per bbl feed and 0.20 to 0.44 CF/CF-hr space velocity. The boiling ranges of the feedstocks were substantially lowered in every test, with the formation of predominantly saturated light fractions, even in the case of the Bunker "C" fuel oil.

The Conradson carbon residue was virtually eliminated for both oils above 850 F average catalyst temperature, indicating removal of constituents which would ordinarily form carbon deposits in any subsequent gasification step. Hydrogen consumptions of over 2000 SCF/bbl were noted, indicating considerable saturation of compounds which would be comparatively unreactive to gasification.

At comparable operating conditions, larger yields of more highly saturated light distillate fractions were obtained from the reduced crude oil, a feed which was not a product of previous thermal treat-

Apparatus and Procedure Used . . .

The pilot unit used for these tests, comprising hydrogen and oil feed systems, hydrocracking and hydrogasification reactors, and product recovery sections, is shown in the diagram.

Hydrogen was fed from storage cylinders, replenished at intervals by compression of commercial-grade cylinder hydrogen in a three-stage compressor. Hydrogen flow was metered by an orifice, with orifice pressure controlled by a self-operating downstream regulator.

Orifice pressure was recorded and orifice differential pressure was converted to a 3 to 15 psi air signal and transmitted to another recorder. A manually-operated metering valve downstream from the orifice was used to set the flow rates.

Oil was fed from a weigh vessel through a reciprocating proportioning pump. In all runs except No. 39, the oil and hydrogen feeds were mixed at room temperature in a mixing valve and introduced into the hydrocracker without preheat. In Run 39, oil and hydrogen were fed separately.

The hydrocracker, constructed of Type 316 stainless steel, was of 5¾ inches O.D., 3 inches I.D., and 40 inches I.L., and was equipped at both ends with self-sealing closures. A ⅜-inch O.D. thermowell extended concentrically into the reactor. Three 12-inch zones of electrical resistance heating, operated by individual pyrometer controllers and variable transformers, were used to heat the reactor.

Reactor and heaters were housed in a furnace, 27 inches square in cross section, with firebrick and insulation filling the space between heaters and walls.

Reactants were passed in downflow over a 19-inch bed of ⅜-inch diameter fused alumina spheres used as a preheat section and located in the top half of the hydrocracker. The bottom half contained a 16-inch catalyst bed supported by a bed of ⅜-inch diameter fused alumina spheres.

The catalyst bed was composed of equal volumes of ⅛-inch cobalt molybdate pellets and ⅛-inch fused alumina pellets, randomly mixed. Two commercial catalysts were used; the major components of these catalysts were 3 to 3.5 weight percent CoO, 9 to 10 weight percent MoO_3, and an alumina support. Reported feed oil space velocities are based on the total volume of catalyst and fused alumina pellets.

When the hydrocracker was operated alone, liquid and gaseous products were cooled and separated in a high-pressure condenser, from which the liquid products were drained periodically to an atmospheric pressure separator, and gases were conducted through high-pressure filters to the back-pressure self-operating regulator. When the hydrocracker and hydrogasifier were operated in conjunction, all products from the hydrocracker were conducted directly to the hydrogasification stage.

The hydrogasifier was also operated in downflow. During the diesel oil test, the hydrocracker was bypassed to allow reactants to flow together from the mixing valve directly to the hydrogasifier. This reactor, constructed of *19-9DL* alloy was of 6 inches O.D., 3 inches I.D. and 35 inches I.L. A ⅜-inch diameter thermowell extended into the reaction zone, entering the head of the reactor ¾ inches from its center.

The reactor was equipped at the top with a self-sealing closure of the same type as had previously been used successfully for high-pressure work at high temperatures (up to 1400F).[22,23] The bottom of the reactor was provided with an integral tailpiece, water-cooled during operation, sealed with a simple gasketed closure. Products were conducted through this bottom opening to a high-pressure condenser-separator, from which liquid products were drained at intervals into an atmospheric pressure separator, and gaseous products were conducted through filters to the back-pressure regulator to be let down to atmospheric pressure. The hydrogasifier was also heated with three 12-inch zones of electrical resistance heating, individually controlled, and housed in a furnace similar in design to the hydrocracker furnace.

The product-recovery system consisted of a liquid trap immediately downstream of the back-pressure regulator, a 100 CF/hr wet-test meter, a continuous recording gravitometer, and a water-sealed holder for collection of a proportional sample of product gas. In addition, gases flashed from product liquids drained from the high-pressure condensers were metered before being vented.

Temperatures were sensed by chromel-alumel thermocouples, and pressures by Bourdon tube gages, at a number of points in both reactors. Reactor temperatures were measured and recorded by means of a potentiometer strip-chart; reactor pressures were also recorded.

Product gases and I.B.P. to 160 C fractions of hydrocracker and hydrogasifier product liquids were analyzed with a mass spectrometer. Other analyses were conducted in accordance with ASTM standards with the following exceptions: hydrocracker product liquid 500-gram distillations were carried out at atmospheric pressure in a method developed at the Institute of Gas Technology with equipment similar to that used in ASTM Method D1160-56T; carbon and hydrogen ultimate analyses were made by combustion train, with the Grace and Gauger[8] modification of ASTM Method D271-44; and hydrogasifier product liquid distillations were carried out by a modification of ASTM Method D20-55.

ment as was the more aromatic Bunker "C" fuel oil. Table 1 gives operating conditions and results and Table 2 presents feed and product analyses.

The effect of average catalyst bed temperature on reduced crude hydrocracking can be seen by a comparison (Fig. 1) of Runs 29-A (850 F) and 39 (895 F). Product compositions were greatly affected; the I.B.P. to 200 C and 200 to 300 C fractions were increased by higher temperature at the expense of the residue fraction, and the total quantity of saturates in these fractions increased by about 15 volume percent. Inspections of each fraction, however, showed that its composition did not change appreciably with temperature.

The effect of average catalyst bed temperature on the composition of the liquid product fractions obtained in Bunker "C" fuel oil hydrocracking is shown in Fig. 2 for Runs 28-A (830 F), 26 (855 F) and 30-A (895 F). Trends similar to those for reduced crude were found, except that at equal temperatures less hydrocracking occurred and the percentage of aromatics in the product was much higher for Bunker "C" fuel oil.

The compositions of the I.B.P. to 160 C and I.B.P. to 200 C fractions from hydrocracking of both residual oils were very similar; however, the heavier fractions differed markedly. For instance, at 895 F average catalyst temperature, the 200 to 300 C fraction from reduced crude consisted of 63 volume percent saturates and 31 volume percent aromatics; comparable data for Bunker "C" operation were 48 volume percent saturates and 46 volume percent aromatics. Similarly, the residue fractions were considerably different for the two oils, and showed properties similar to those of the respective feedstocks, except in Conradson carbon residue.

The effect of catalyst bed temperature on total liquid products properties is shown in Figure 3. Conradson carbon residue was almost eliminated by increases in temperature from 830 to 855 F. Hydrocracking was considerably increased by increases in temperature from 830 to 895 F; this is shown by decreases in C/H weight ratio and sulfur content, and an increase in API gravity.

Runs 29-A and B (reduced crude feed), and 30-A and B (Bunker "C"

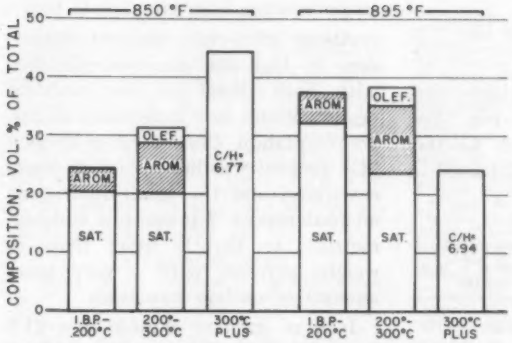

FIGURE 1—Higher temperatures produce more lighter fractions at the expense of the residual fraction.

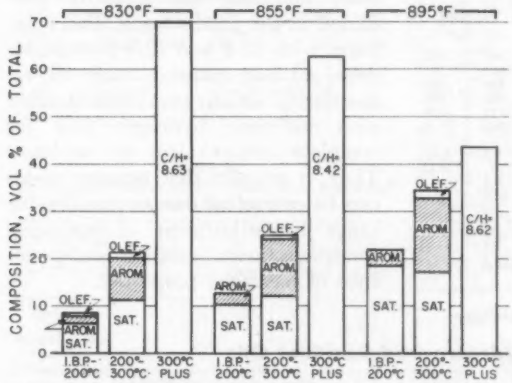

FIGURE 2—Bunker "C" fuel oil yields more aromatics when hydrocracked at higher temperatures.

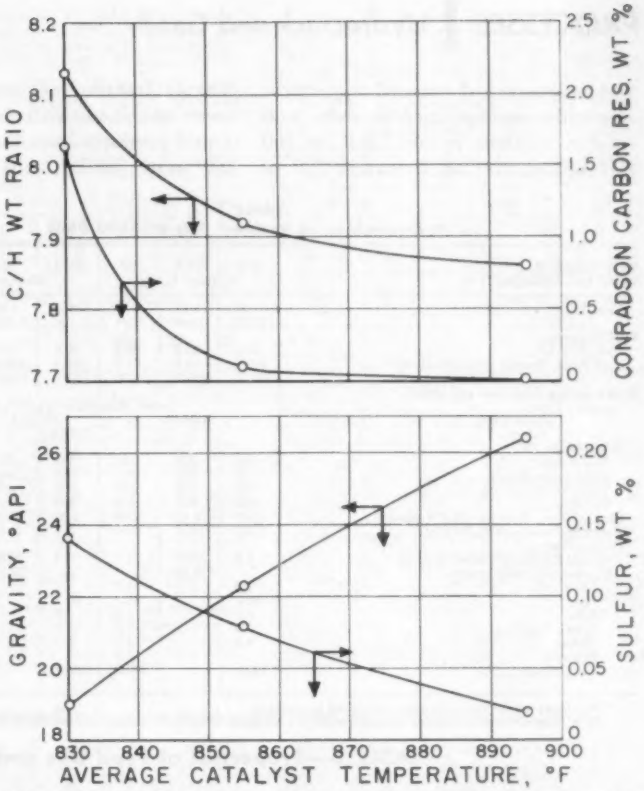

FIGURE 3—Conradson carbon residue was almost eliminated by increasing the temperature of cracking. At the same time, hydrocracking was increased.

fuel oil feed) were continuous runs, each of twenty hours total duration, with the "A" period used only for hydrocracking to prepare a large enough sample for analysis. Small samples of hydrocracked oil were taken at intervals during the "B", or combination hydrocracking-hydrogasification period; gravities and ultimate analyses of these samples showed that composition was essentially constant during Run 29 with reduced crude.

However, during Bunker "C" fuel oil tests, some decline in product quality has been observed, corresponding to a loss in gravity of about 0.2 degrees API per hour.

A run length of 20 hours was not sufficient for evaluation of catalyst regeneration requirements in operations with either residual oil. Almost negligible carbon depositions were observed during the reduced crude tests. For the more refractory Bunker "C" fuel oil feed, the necessity for use of higher operating temperatures resulted in much higher carbon depositions.

Analyses of selected catalyst batches indicated that these depositions were at only about one half of the level reached before regeneration was required with other residual feeds.[10] However, it appears that this observation does not permit estimation of regeneration requirements, since it has been reported that equilibrium carbon deposition is reached early in hydrogenation runs, and is no greater after 500 hours of operation.[10]

Hydrogasification of Diesel Oil and Hydrocracked Residual Oils

Hydrogasification results at 1500 psig and 1400 F for the two hydrocracked residual oils (Runs 29-B and 30-B, Tables 1 and 2) and of a typical diesel oil, selected because of its fairly reproducible composition, are summarized in Table 3.

The high paraffinicity and low carbon-forming tendencies of the diesel oil made catalytic pretreatment unnecessary. Feed rates, feed ratios, and hydrocracking pretreatment conditions, in the case of the residual oils, were chosen to yield product gases of comparable quality (891 to 924 Btu/SCF). The use of hydrogen/oil feed ratios of about 100 percent of the requirements for complete conversion of the oil to methane was possible for both diesel oil (Run 31), and reduced crude hydrocracked at 895 F (Run 29-B).

However, the greater reactivity of diesel oil permitted feed rates of over twice those for reduced crude. Feed rates for hydrocracked Bunker "C" fuel oil (Run 30-B) were equivalent to those for hydrocracked reduced crude; in this case, reduction in product gas heating value due to the lower reactivity of the feed to hydrogenolysis was avoided by a reduction in feed ratio to 73 percent of the stoichiometric requirements for complete conversion to methane.

Product gases from all feeds consisted primarily of methane, ethane and hydrogen. Compositions were very similar for the diesel oil and hydrocracked reduced crude feeds; the product gas from hydrocracked Bunker "C" contained less ethane, however. This tendency of more aromatic feedstocks to yield gases of lower ethane contents was established in previous work in a batch system with a variety of pure compounds.[23]

Liquid products from diesel oil

and hydrocracked reduced crude were also quite similar; high benzene and toluene contents in the I.B.P. to 160 C fraction, and an aromatic 200 to 300 C fraction of appreciable size, were obtained with both oils. The liquid products from Bunker "C" fuel oil were similar, but contained a larger residue fraction (355 C plus).

About 90 weight percent conversion to high-Btu gas was obtained with both diesel oil and reduced crude without any indications of carbon formation. Conversion of Bunker "C" fuel oil was limited by its lower reactivity, and the lower hydrogen/oil feed ratio (73 percent of stoichiometric), to slightly more than 70 weight percent, with a very small amount of carbon formation.

It is of interest to note that 21.6 percent of the Bunker "C" fuel oil carbon content was converted to benzene, including the quantity contained in the product gas. This compares with 12.2 and 12.5 percent for diesel oil and reduced crude oil, respectively, which were hydrogasified with sufficient hydrogen feed for complete conversion to methane. Thus, it appears that benzene yields can be controlled over a considerable range by adjustment of operating conditions with relative independence of feedstock properties.

TABLE 1
Hydrocracking of Residual Oils at 1500 PSIG

RUN NUMBER	29-A	29-B	39	28-A	26	30-A	30-B
FEED OIL DESIGNATION	Reduced Crude			Bunker "C" Fuel Oil			
Rate, lb./hr.	1.73	1.69	1.78	0.886	1.69	1.70	1.66
gal/hr.	0.225	0.219	0.231	0.106	0.202	0.204	0.199
Feed Hydrogen:							
Rate, SCF/hr.	55.3	53.3	55.2	30.6	67.3	46.0	45.4
Feed Ratio, Percent of Stoichiometric*	100.8	99.7	98.0	92.4	106.9	72.6	73.4
SCF/bbl of Oil	10319	10202	10030	12079	13969	9484	9593
Hydrocracking Conditions and results:							
Catalyst, Type	Cobalt Molybdate—⅛ Inch Pellets						
Preparation	Tabletted			Extruded		Tabletted	
Volume, CF				0.0706			
Temperature, °F.:							
Top of Bed	800	830	855	837	793	860	880
Eight Inches Down	860	900	925	859	888	915	920
Twelve Inches Down	865	925	890	809	866	885	880
Bed Average	850	895	895	830	855	895	905
Feed Oil Space Velocity, CF/CF cat-hr	0.43	0.42	0.44	0.20	0.38	0.39	0.38
Hydrogen Consumption, SCF/bbl.	1705	N.D.	1487	974	N.D.	2041	N.D.
Product Gas:							
Weight Percent of Carbon in Feed	7.5	N.D.	7.8	4.1	N.D.	9.5	N.D.
Composition, mole Percent	....	N.D.	....	....	N.D.	....	N.D.
$N_2 + CO$	1.0	....	1.0	....	....	0.7	....
H_2	95.0	....	95.2	97.7	....	92.2	....
CH_4	2.2	....	1.8	1.5	....	4.4	....
Higher Paraffins	1.6	....	1.8	0.4	....	2.5	....
Olefins	0.2	....	0.1	0.4	....	0.2	....
Benzene	....	....	0.1	....	....	....	....
Total	100.0	....	100.0	100.0	....	100.0	....

* Stoichiometric for complete conversion of oil to methane.
SCF—Gas volume in standard cubic feet at 60° F., 30 inches of mercury pressure and saturated with water vapor.

TABLE 2—Properties of Feed Oils and Hydrocracked Residual Oils

OIL DESIGNATION	Diesel Oil	Reduced Crude	Hydrocracked Reduced Crude		Bunker "C" Fuel Oil	Hydrocracked Bunker "C" Fuel Oil		
RUN NUMBER	Feed	Feed	29-A	39	Feed	28-A	26	30-A
Properties of Total Oil:								
Gravity, 60°F/60°F	0.838	0.925	0.836	0.811	1.001	0.940	0.920	0.896
°API	37.3	21.4	37.8	42.9	9.9	19.0	22.3	26.4
Viscosity, CS at 100° F	2.862	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
SS at 122° F	N.D.	247.0 (Univ.)	35.2 (Univ.)	31.9 (Univ.)	93.7 (Furol)	51.5 (Univ.)	41.0 (Univ.)	34.4 (Univ.)
Ultimate Analysis, Weight Percent:								
Carbon	86.27	85.43	85.00	85.35	89.55	88.54	87.87	87.22
Hydrogen	13.50	12.13	12.80	12.91	10.52	10.89	11.10	11.09
Sulfur	0.30	1.90	0.12	0.00*	0.86	0.14*	0.08*	0.02
Ash	0.000	0.060	N.D.	N.D.	0.024	N.D.	N.D.	N.D.
Carbon/Hydrogen Weight Ratio	6.39	7.04	6.64	6.61	8.51	8.13	7.92	7.86
Conradson Carbon Residue, Weight Percent	nil	4.42	0.03	0.00*	10.73	1.64*	0.13*	0.02
Initial Boiling Point, °C.	194	60‡	56	48	90‡	51	54	57
Properties of Oil Fractions:								
Initial Boiling Point—160° C Fraction:								
Weight Percent of Total Oil	.....	0.5‡	13.8	20.0	0.5‡	5.3	5.1	9.0
Composition, Mole Percent:								
Cyclopentadiene (Mono and Di)	.....	.....	3.6	0.1	.....	0.7	0.4	0.5
Benzene	.....	.....	1.9	2.2	.....	1.4	1.9	2.0
Toluene	.....	.....	4.0	4.5	.....	3.0	2.8	4.3
C_8 Aromatics	.....	.....	3.4	2.7	.....	2.9	2.6	2.8
C_9 Aromatics	.....	.....	3.1	2.7	.....	3.4	2.4	3.3
Higher Aromatics	.....	.....	0.6	0.5	.....	0.8	0.6	0.7
Saturates+	.....	.....	83.4	87.3	.....	87.8	89.3	86.4
Initial Boiling Point—200° C Fraction:								
Weight Percent of Total Oil	.....	0.6‡	21.3	32.5	1.2‡	6.2	9.4	16.4
Gravity, 60° F/60° F	.....	.....	0.765	0.748	.....	0.760	0.759	0.757
°API	.....	.....	53.5	57.7	.....	54.7	54.9	55.4
Sulfur, Weight Percent	.....	.....	N.D.	0.00	.....	N.D.	0.01	N.D.
Olefins, Volume Percent++	.....	.....	0.5	0.5	.....	7.2	1.6	0.5
Aromatics, Volume Percent++	.....	.....	15.6	14.1	.....	18.0	16.6	16.5
Saturates, Volume Percent++	.....	.....	83.9	85.4	.....	74.8	81.8	83.0
200°—300° C Fraction:								
Weight Percent of Total Oil	.....	4.4	31.8	39.7	8.5	20.1	24.3	35.2
Gravity, 60° F/60° F	.....	.....	0.846	0.842	.....	0.890	0.890	0.892
°API	.....	.....	35.8	36.6	.....	27.5	27.5	27.1
Ultimate Analysis, Weight Percent:								
Carbon	.....	.....	86.67	86.96	.....	87.85	87.97	88.30
Hydrogen	.....	.....	12.68	12.77	.....	11.60	11.58	11.46
Sulfur	.....	.....	N.D.	0.00	.....	0.06	0.05	N.D.
Carbon/Hydrogen Weight Ratio	.....	.....	6.84	6.81	.....	7.57	7.60	7.71
Olefins, Volume Percent++	.....	.....	8.8	6.8	.....	4.5	2.8	6.6
Aromatics, Volume Percent++	.....	.....	27.0	30.6	.....	46.8	48.6	45.8
Saturates, Volume Percent++	.....	.....	64.2	62.6	.....	48.7	48.6	47.6
Residue Fraction:								
Weight Percent of Total Oil	.....	94.8	46.2	26.2	89.9	73.0	65.4	47.4
Gravity, 60° F/60° F	.....	.....	0.870	0.880	.....	0.977	0.964	0.976
°API	.....	.....	31.1	29.3	.....	13.3	15.3	13.5
Ultimate Analysis, Weight Percent:								
Carbon	.....	.....	86.64	86.83	.....	89.05	89.04	89.26
Hydrogen	.....	.....	12.80	12.52	.....	10.32	10.57	10.35
Sulfur	.....	.....	N.D.	0.00	.....	0.17	0.10	N.D.
Carbon/Hydrogen Weight Ratio	.....	.....	6.77	6.94	.....	8.63	8.42	8.62
Conradson Carbon Residue, Weight Percent	.....	3.60	0.06**	0.01	12.54	2.25	0.20	0.04**

* Calculated from values measured for product liquid fractions.
** Calculated from values measured for total product liquid.
\+ May include small amounts of olefins.
++ FIA Method, ASTM D1319-56T.
‡ Values affected by trace of water in sample.

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TABLE 3
Hydrogasification of Distillate and Residual Oils at 1500 PSIG

RUN NUMBER	31	29-B	30-B
Feed Oil Designation	**Diesel Oil**	**Reduced Crude**	**Bunker "C"**
Rate, lb./hr	3.50	1.69	1.66
gal/hr.	0.501	0.219	0.199
Feed Hydrogen:			
Feed Rate, SCF/hr.	99.2	53.3	45.4
Feed Ratio, Percent of Stoichiometric*	96.0	99.7	73.4
SCF/bbl of Oil	8316	10202	9593
Run Conditions and Results:			
Temperature, °F			
Zone 1	985	1330	1250
Zone 2	1390	1380	1390
Zone 3	1420	1320	1350
Residence Time, sec.	169	334	422
Hydrogen Consumption, SCF/bbl.	6275	6560	5750
Conversion, Weight Percent of Oil + H_2 Feed:			
Gas	90.6	90.2	71.7
Liquid	9.4	9.8	27.7
Carbon	Nil	Nil	0.6
Product Gas Yield, SCF/bbl.	8194	9005	7938
SCF/CF Reactor-hr.	673.8	324.5	258.9
MBtu/CF Reactor-hr.	613.0	299.8	230.7
Net Btu Recovery, MBtu/gal**	114.3	120.5	94.4
Product Gas Properties:			
Composition, mole Percent			
$N_2+CO+CO_2+H_2S$	0.3	0.2	0.1
H_2	24.9	21.5	22.7
CH_4	66.5	70.3	72.5
C_2H_6	7.0	7.1	3.9
Higher Paraffins	0.1	...	...
C_2H_4	0.2	0.2	0.1
Benzene	1.0	0.7	0.7
Total	100.0	100.0	100.0
Heating Value, Btu/SCF	910	924	891
Specific Gravity, (Air = 1)	0.493	0.502	0.480
Product Liquid Properties:			
Gravity, 60°F/60°F	0.951	0.929	0.969
°API	17.3	20.8	14.5
Sulfur, Weight Percent	0.12	0.08	0.17
Free Carbon Content, Weight Percent	0.01	0.01	0.20
Initial Boiling Point, °C.	79	78	78
Distillation, Wt. Percent:			
I.B.P.—106° C.	61.3	73.0	60.1
160–200° C.	1.0	1.5	1.7
200–300° C.	22.5	12.7	14.7
300–355° C.	5.7	2.9	3.7
Residue	8.3	7.9	18.6
Carbon/Hydrogen Weight Ratio of 160° C—Plus Fraction	14.96	16.32	16.77
I.B.P.—160° C Frac. Comp., mole Percent:			
Benzene	90.1	93.5	94.6
Toluene	5.3	4.4	3.8
Ethylbenzene	0.9	0.5	0.4
Indene	0.1	...	...
Naphthalene	2.4	1.6	1.2
Unknown	1.2	...	...
Total	100.0	100.0	100.0

* Stoichiometric for complete conversion of oil to methane.
** Heat of combustion of product gas less heat of combustion of feed hydrogen.
SCF—Gas volume in standard cubic feet at 60° F, 30 inches of mercury pressure and saturated with water vapor.

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Literature Review on Hydrocracking and Dearomatization

The method of oil pyrolysis in the presence of feed hydrogen has been identified in the literature as *hydrogasification*.[15,16,21,22,23] The first phase of a research program on the use of this method in the production of natural gas substitutes led to the development of a continuous process for gasification of natural gasoline and lower-boiling paraffinic petroleum fractions in a tube furnace, with 50 to 100 SCF of feed hydrogen per gallon of feedstock at pressures of 50 to 100 psig.[15]

To permit continuous hydrogasification of a greater range of feedstocks, including heavy residual oils, the program has now been extended to investigation of higher pressures (up to 1500 psig), and higher hydrogen/oil feed ratios (in excess of 300 SCF/gal for a Bunker "C" fuel oil). On the basis of batch reactor test results,[22] it was anticipated that under these conditions, high conversions of petroleum oils to gaseous products consisting primarily of methane could be achieved if carbon formation from residual oils could be avoided by means of a preliminary hydrocracking step.

Hydrocracking has been found to occur to a limited extent during partial or total saturation of condensed-ring aromatics in catalytically cracked recycle oils.[1,12,24,28,29] Hydrocracking-dearomatization of residual and distillate fuels at high pressures (about 9000 psig) has also been reported, usually in connection with vapor-phase hydrogenation of middle oils derived from coal.[9]

However, for studies of upgrading residual oils for subsequent gasification, several references on hydrocracking-dearomatization at medium pressures (below about 3000 psig) are more significant. This major adaptation of hydrogenation was described as early as 1930; conversion of heavy, high-sulfur content, asphaltic crudes and refinery residues to gasoline and sulfur- and asphalt-free distillates without coke formation was claimed by Haslam, Gohr, Russell and Byrne,[2,7,11] but few data were given.

Most publications on this subject have appeared in the last six years, and have usually involved cobalt molybdate catalysts. Important features of most of this recent work are given in the accompanying table. Temperatures between 800 and 900F, and pressures above 500 psig, have usually been employed. With low space velocities (1.0 CF/CF cat-hr or less), and high hydrogen/oil feed ratio (usually near 6000 SCF/bbl), large reductions in boiling range and specific gravity have been obtained, together with considerable hydrogen consumption. Catalyst fouling has not appeared to be a major operating problem; as high as 1000 hours between regenerations, and six months total life, have been stated as feasible for cobalt molybdate.[10,20]

Practically regeneration-free operation, with increased yields of low-boiling products, has been obtained when residual feedstocks were mixed with diluents, including hydrogen transfer agents.[26] It is of interest to note that quartz chips and cobalt molybdate catalyst have given similar conversions to lower-boiling constituents under similar operating conditions. However, the Conradson carbon content of the residue from a gasoline distillation was not reduced when quartz was used.[26]

The effect of temperature on hydrocracking has been considered by a few authors.[4,5,13,25] Below about 800F, hydrogenation refining reactions predominated, with little hydrocracking occurring. Above about 900F, hydrogen consumption greatly increased, accompanied by much larger gas formation, and the aromatic content of the product liquid increased rapidly as a result of naphthene dehydrogenation. Up to 900F, carbon deposition was not excessive, even at high gas formation.

These literature data indicated that residual oils, which ordinarily form large quantities of tar and carbon byproducts during any thermal gasification process, could be readily upgraded by catalytic hydrogenation. It appeared that suitable

Literature Review on Hydrocracking and Dearomatization

AUTHORS	Feedstock	Temperature, °F.	Pressure, psig	Space Velocity CF/CF-Hr.	Hydrogen/Oil Ratio, SCF/Bbl.	Catalyst	Diluent	Hydrogen Consumption SCF/Bbl.
Hoog, et al[13]	Shale Oil	842–887	2204	Not given	Not given	Cobalt Molybdate	None	1850
Thorne, et al[27]	Shale Oil	825	1000	1.0	Not given	Cobalt Molybdate	None	Not given
Smith and Landrum[25]	Shale Oil	750 and 770	3000	0.5	6000	Tungsten Nickel Sulfide	None	About 1800
Crecelius, et al[5]	Shale Oils	784–903	3000	1.0	6000	Cobalt Molybdate	None	1540–2450
Cottingham, et al[4]	Shale Oil	759–1010	3000	1.0	6000	Cobalt Molybdate	None	About 2200
McAfee, et al[18,19]	Residuals and Crudes	800–850	500–1000	0.5–2.0	2500–10,000	"Supported Metallic"	None	426–1140
Stevenson and Heinemann[26]	Diluted Residuals	815–820	3500	1.0	2300	Cobalt Molybdate	Butanes	677
Stevenson and Heinemann[26]	Diluted Residuals	815–820	3500	1.0	2300	NiO or NiS on Silica-Alumina	Butanes	346–483
Law[14]	Asphaltic Crudes	734	Max. 2100–4450 (Batch System)	.....	Not given	"Commercial Grade Nickel"	None	Not given
Gwin, et al[10]—Manne, et al[20]	Fluxed Asphalts	725–825	400–800	0.5–2.0	1500–4500	Cobalt Molybdate	Heating Oil	300–1000
Clough[3]	Coal Tar Oils	842	1800	1.0 Kg/liter-hr.	Not given	Ni on Silica-Alumina	None	Not given

conditions could be chosen to optimize hydrocracking and dearomatization reactions in order to remove the precursors of carbonaceous deposits, and to achieve considerable saturation of aromatic contituents to compounds more reactive to subsequent hydrogasification.

Hydrogasification studies initially were limited to tube furnace operation at pressures of 30 to 60 psig.[15,16] At this pressure level, only low molecular weight paraffinic hydrocarbons could be completely converted to natural gas substitutes. The reduced reactivity of feedstocks containing a substantial percentage of non-paraffinic hydrocarbons limited the amount of hydrogen feed which could be utilized in hydrogenolysis reactions to a fraction of the stoichiometric quantity required for complete gasification.

Thus, the maximum hydrogen/oil feed ratios which could be employed were determined by the allowable breakthrough in the production of 1000 Btu/SCF gas. At reaction temperatures of 1300 to 1550F, 2 to 10 seconds reaction time and feed ratios ranging from 100 SCF/gal for kerosine to less than 60 SCF/gal for Bunker "C" fuel oil, the product gases had substantially higher methane and ethane content, and considerably lower olefin content, than those obtained in conventional atmospheric pressure operation in the absence of feed hydrogen.

However, nongaseous product formation was still substantial. These nongaseous products included increased amounts of tar and pitch components, and carbon, as the molecular weight and aromaticity of the feedstock increased.

The batch hydrogasification of distillate and residual petroleum oils to high-heating-value gases was subsequently investigated at higher pressures (2000 to 4400 psig), and 1200 to 1350F, in an effort to obtain increased conversions to essentially olefin-free gases.[22] By using much higher hydrogen/oil feed ratios (up to 299 SCF/gal) than in the low-pressure continuous tube furnace tests, it was possible to convert up to 90 weight percent of a typical Bunker "C" fuel oil, and to approach complete conversion of a reduced crude oil to 900 to 1100 Btu/SCF gases consisting primarily of methane.

In November, 1956, Dent and coworkers of the British Gas Council reported their experiments on the hydrogenation of oils to gaseous hydrocarbons at pressures up to 50 atmospheres, and temperatures between 700 and 900C (1292 and 1652F).[4]

In this work, the oil feed was supplied to a bed of coke particles fluidized with hydrogen. Conversions to 500 to 600 Btu/SCF gases were 82.1, 78.9 and 68.5 weight percent for gas oil, crude oil and heavy fuel oil, respectively. Hydrogen/oil feed ratios were quite high—about 350 to 550 SCF/gallon. The low heating value of the product gases was partly due to hydrogen dilution caused by these high feed ratios.

The reactions of pure compounds related to petroleum oils, while undergoing hydrogasification in a batch system, were studied recently to provide fundamental information for pilot plant work reported here.[23] Six-carbon to twelve-carbon normal paraffins, six-carbon cyclic hydrocarbons, and ten-carbon condensed ring hydrocarbons were reacted at an initial pressure of 1275 psig, feed ratio of 30 SCF/lb, and temperatures up to 1300F. Gasification threshold temperatures were reported, and data on gaseous product formation were presented.

The major products, methane and ethane, were produced in nearly equimolar quantities during the initial phases of the hydrogenolysis of paraffins; less ethane was produced from cyclic compounds, particularly aromatics. With the exception of benzene feed, it appeared that this initial equimolar methane and ethane formation occurs rapidly via a three-carbon intermediate, of which propane is the stable evidence.

As propane disappears with increases in residence time and temperature, hydrogenolysis of ethane takes place, and methane formation occurs at a lesser rate via a two-carbon intermediate, of which ethane is the stable evidence. Reaction of benzene with hydrogen was not appreciable at the temperatures at which the other hydrocarbons were converted. It appeared that methane formation from benzene proceeds principally through a two-carbon intermediate; the higher temperature required does not seem conducive to three-carbon intermediate formation.

The final gaseous product distributions were interpreted on the basis of the same secondary gas-phase reaction system employed in a previous study of hydrocarbon pyrolysis,[17] indicating the considerable similarity between pyrolysis and hydrogasification (pyrolysis modified by addition of feed hydrogen).

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Linden

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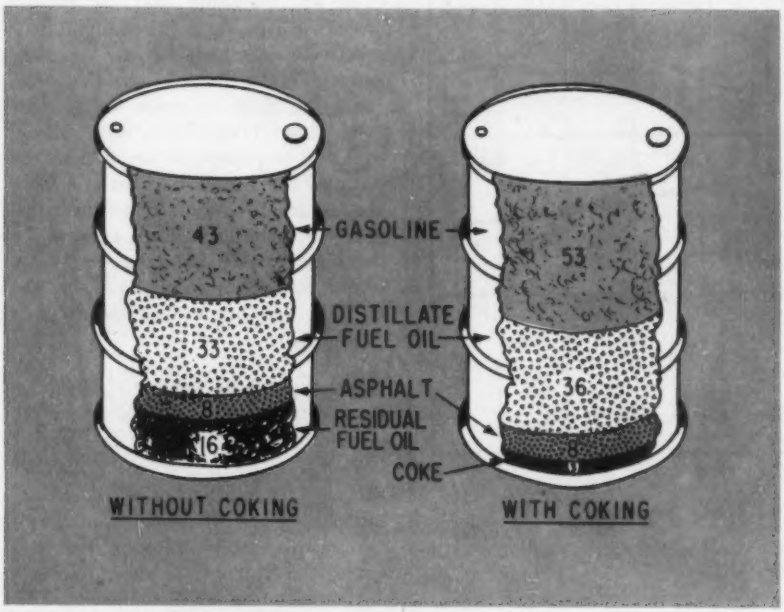


FIGURE 1—Coking eliminates some of the residual fuel oil production and increases the production of gasoline and distillate fuel oil.

Fluid Coking Shifts Product Distribution

See how fluid coking can be used to change residual fuel oil into high octane gasoline. These data also show uses for the by-product coke.

R. M. Cornforth
Kaiser Engineers
Oakland, Calif.

THE DEMAND FOR residual fuel oil has continued to be a decreasing percentage of the total liquid fuel demand since World War II. The refining industry has developed various processing methods to reduce the yield of residual oil and to increase the yield of gas oil suitable as charge stock for catalytic cracking. This in turn has increased the yield of high octane gasoline and distillate fuel oils to meet the changing market requirements. The processes used to make the shift in product distribution include visbreaking, vacuum distillation, propane deasphalting, catalytic cracking of reduced crude, and delayed coking.

A recent effort to produce a maximum reduction in residual fuel oil yield is the fluid coking process, developed and licensed by Esso Research and Engineering Company. The first commercial application of this continuous process was installed by The Carter Oil Company at its Billings, Mont., refinery, where a 3800-barrel-per-day fluid coker went on stream in late 1954. Subsequently, in the fall of 1955, a 10,000-barrel-per-day fluid coker went into operation at Esso Standard Oil Company's Baltimore refinery.

A total of eight fluid cokers in the United States and foreign countries currently are in operation or are under construction. The largest units presently in operation are Tidewater Oil Company's similar 42,000-barrel-per-day units at Avon, Calif., and Delaware City, Del.

Yields from the fluid coking process depend upon the character of the feed stock, principally upon the Conradson carbon of the feed. Feed stocks evaluated in pilot plant operations cover a range from minus 6 degrees to 21 degrees API and 5 to 41 weight percent Conradson carbon. Typical yields from fluid coking when charging a vacuum residuum from California crudes are shown on Table 1. These yields are on an ultimate basis, with the gas oil above 1015 F. being recycled to the process.

TABLE 1—Fluid Coking of Vacuum Residuum From California Crudes

Feed Inspections	
°API	5.6
Conradson Carbon, Weight Percent	22.5
Sulfur, Weight Percent	1.7
Ultimate Yields	
Propane and Lighter, Weight Percent	8.0
Butanes, Volume Percent	2.2
Debutanized Gasoline, Volume Percent (430° F E.P., 76 F-1 Octane, 0.6 Wt. % S.)	19.3
Gas Oil, Volume Percent (1015° F E.P., 1.2 Wt. % S.)	55.0
Coke, Weight Percent	26.0

Usually the coker gasoline will require further treatment to increase its octane number. If the feed stock is high in sulfur, treatment is needed to reduce the sulfur content of the naphtha. Catalytic reforming of the coker gasoline in a blend with

These other articles on Fluid Coking also appeared in PETROLEUM REFINER:

"New Fluid Coking Process Unveiled," Vol. 32, No.12 (December, 1953), pp 127-130.

"New Data on Fluid Coking," Vol. 33, No. 11 (November, 1954), pp 157-160.

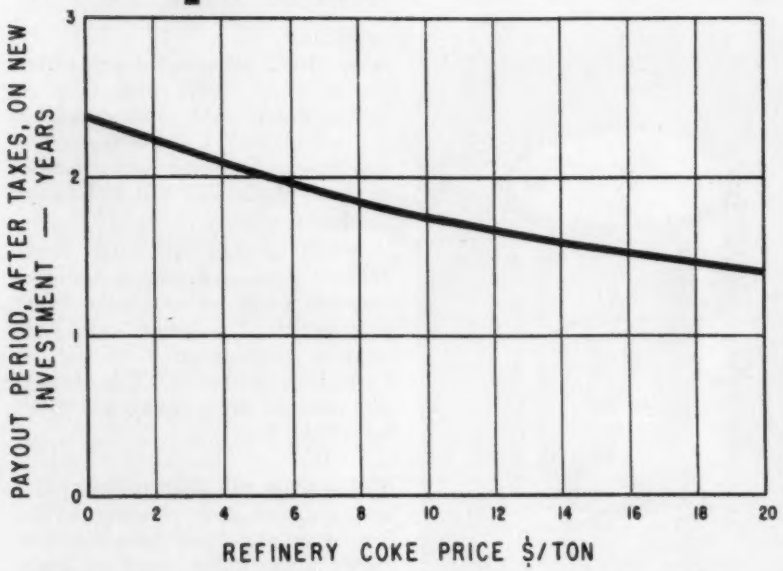


FIGURE 2—The payout period on the fluid coking facilities is relatively insensitive to the coke price.

straight-run gasolines sometimes is indicated.

The gas oil is suitable for charge stock to a catalytic cracking unit, although coke yield in the catalytic cracker from this gas oil is greater than from a virgin gas oil of equivalent gravity and boiling range. Alternatively, a coker gas oil cut of the desired boiling range may be hydrogenated for heating oil.

The effect on refinery yields of installing a fluid coker in a typical refinery is shown in Figure 1. It will be noted that, in this case, coking results in the elimination of residual fuel oil production with a substantial increase in gasoline production and a small increase in distillate fuel oil production.

The economic attractiveness of a coking process lies in its ability to convert low value heavy residual oil into gasoline and light distillates. Another advantage of a coking unit is the flexibility it adds to the refinery operation, so that the refinery is able to adjust its yields of light and heavy products according to seasonal demand.

The economics of adding a fluid coker to a refinery will depend of course on the specific refinery situation with regard to refinery product realizations, existing processing operations, and similar pertinent conditions. Figure 2 shows the effect of refinery coke price on new investment payout for a typical refinery situation in which a 10,000-barrel-per-day fluid coker and necessary accompanying facilities are added to an existing 65,000-barrel-per-day refinery.

The refinery price basis for this situation is as follows:

Gasoline .....13 cents per gallon
Distillate fuel oil.....9 cents per gallon
Bunker C fuel oil.....$2.10 per barrel

An allowance has been made for the costs involved in converting the coker gas oil to gasoline by catalytic cracking and for further processing the coker gasoline by means of catalytic reforming.

It will be noted that the payout period on the fluid coker facilities is relatively insensitive to the coke price. This is because, in this case, the coke yield on crude oil is relatively low. Usually a fluid coking unit can or cannot be justified on the basis of the increase in income from the lighter products. The coke price received, assuming that a market for the coke can be arranged, normally is not the determining factor in the decision whether or not to install a coking unit.

The by-product coke produced by the fluid coking process is a new industrial material in the form of a dry, hard, granular solid, having roughly the particle size of coarse sand. It is composed of approximately 90 percent carbon, with the other constituents varying, depending upon the source of the crude. The coke flows freely and can be transported and stored with properly designed materials handling systems.

From the standpoint of the petroleum refining industry, the problem has been the development of suitable markets that will utilize the potential of this new material. A substantial amount of research and development work directed at new market applications for fluid coke has been and is being carried on by different groups in several fields of industry. Although it is likely that some high value usages can be developed, such as carbon electrodes for use in the electrolytic reduction of alumina to aluminum, it appears that the ultimate base load for this material will be as a fuel. In this use it should have wide application because of its high heating value, its low volatile matter, and low ash content. It has been successfully burned in a rotary kiln and in steam boiler installations.

As an industrial fuel, fluid coke has been used in full-scale combustion tests in rotary kiln operations at the Permanente, Calif., plant of Permanente Cement Company. The chemical and screen analysis of this coke as received is shown in Table 2.

Preliminary runs gave drop-out of large coke particles, some of which were approximately ⅜-inch in diameter. It was decided the coke should be ground to a more uniform size for

TABLE 2—Analysis of Billings Coke Used in Permanente Kiln Test

CHEMICAL	Percent Weight
Carbon	89.1
Sulfur	6.0
Volatile (1742° F)	3.8
Ash	0.16
Vanadium	0.03
Nickel	0.01
Net Heating Value BTU/Lb	14,300

SCREEN Screen Size	Cumulative % Retained
8	5.2
35	11.1
65	48.6
100	80.1
200	95.8

subsequent testing. Accordingly, several tons were ground having the screen analysis shown in Table 3.

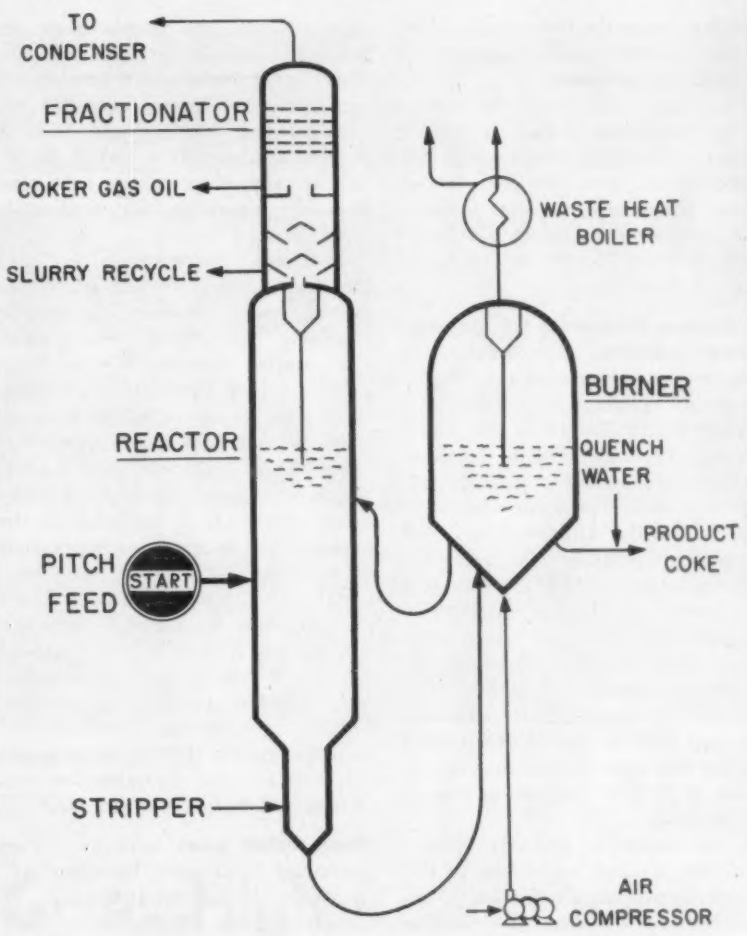
TABLE 3—Screen Analysis—Billings Coke Used in Permanent Kiln Test

AFTER GRINDING	
Screen Size	**Cumulative % Retained**
16	0
50	1.0
65	11.0
80	20.1
100	50.3
200	75.5
Weight	**Lb/Cu. Ft.**
Loose	55.7
Tamped	63.4

The methods developed by Kaiser Engineers indicate that on a commercial basis this grinding can be done for less than 30 cents per ton.

A run with the ground coke was made with the input of primary air for coke combustion at 600 cubic feet per minute and 80 pounds per square inch gage, and with 50 percent natural gas for the auxiliary fuel. The color, shape of the flame, lack of fallout, and ignition 10 feet beyond the nozzle indicated a performance almost identical with 100 percent gas flame. This was followed with another run under similar conditions in which the maximum firing rate of 6¾ tons per hour was attained after a rapid build-up of coke flow, during which time the gas rate was reduced accordingly. Auxiliary firing of gas in reduced quantities was necessary to maintain input heat balance; but for several intervals of short duration the gas was turned off, permitting the kiln to operate entirely on coke. The normal natural gas fuel consumption of this kiln is approximately 212 Mcf/hr with 1100 Btu/scf gas or 233,200,000 Btu/hr. Since the heating value of coke is 14,300 Btu/lb, about 17 percent of the normal gas flow was required to maintain the kiln temperature. During the test the kiln temperatures rose from approximately 2680 F. to about 2800 F.

From the test data and observations, it would appear that if all six kilns of this plant were operating wholly on fluid coke, the total sulfur released to the atmosphere probably would not be objectionable, assuming there is a 50-50 split of the sulfur between the stack gases and in the dust collected by the precipitators. The amount of sulfur found in the clinker was insignificant. Any reduction of the total coke burned or a reduction



How Fluid Coking Works

Fluid coking is a continuous noncatalytic process in which the feed stock, usually consisting of a heavy residual oil, is cracked into gas, gasoline, gas oil, and coke. The feed stock is sprayed into a bed of small particles of coke which circulate continuously through the unit in a fluidized state.

The simplified flow diagram shows the unit consists essentially of a reactor vessel, where coking of the feed stock takes place, and a heater or burner vessel, where some of the coke formed in the process is burned to supply the necessary heat. The coke particles are formed continuously in the process and are allowed to grow to the size of coarse sand.

The temperature in the reactor vessel is approximately 950 F., and the pressure is in the order of 5-10 psig. The coke particles in the reactor are fluidized by means of steam added to the bottom as well as by the cracked vaporized products formed in the reactor. Hydrocarbon vapors leaving the reactor go through a cyclone to separate entrained coke particles and then pass to a scrubber and fractionator, where the gas, gasoline, and gas oil are separated. This fractionator can be located on top of the reactor vessel as shown in the diagram, but sometimes it may be preferable from a construction and maintenance standpoint, to locate the fractionator at ground level.

Air is added to the heater vessel to support combustion at a temperature of about 1125 F. About five percent of the coke, based upon the feed, is burned in this heater vessel to supply the necessary heat.

Coke particles which have grown to the desired size are removed as product coke and replaced with smaller seed coke particles. An integral grinding system in the reactor furnishes the necessary seed coke. Net product coke is quenched by water injection to a temperature satisfactory for handling.

of sulfur below the 6 percent analysis of this sample would minimize the air pollution problem.

Fluid coke also has been burned on an experimental basis in several steam generating stations in the United States, and the coke output of the Esso Baltimore unit is being used for fuel in the Essex Station of Public Service Electric & Gas Company of New Jersey.

As Carbon Electrodes for the aluminum industry, approximately 0.6 pounds of raw petroleum coke is used per pound of aluminum produced.

Since World War II the aluminum industry has undergone a phenominal expansion which is still continuing. Currently, primary aluminum capacity in the United States and Canada is 2,469,000 tons annually, with an additional 1,112,000 annual tons under construction or definitely planned. Therefore, petroleum coke requirements for the aluminum industry are now approximately 4100 tons per day for the U. S. and Canada, and will increase to about 6000 tons per day upon the scheduled completion in 1959 of the present expansion program.

In the aluminum industry petroleum coke is used principally in the manufacture of the anodes which are consumed in the electrolytic reduction process.

Green coke produced by the delayed process contains from 8 to 14 percent volatile matter and cannot be used directly because excessive shrinkage would occur in the anode baking process. Calcining usually is done in rotary kilns at 2400 F. to 2800 F. and results in devolatilization, densification, and conversion to electrically conducting carbon.

The Soderberg continuous anode process is used at the Chalmette, Louisiana, reduction plant of Kaiser Aluminum & Chemical Corporation near New Orleans, the largest single reduction plant in the country. The Soderberg paste at this plant consists of a mixture of approximately 70 percent calcined coke aggregate and 30 percent coal tar pitch. A typical analysis of calcined petroleum coke used in anode manufacture is given in Table 4.

Laboratory work using fluid coke has been done at the Mead, Washington, plant of Kaiser Aluminum & Chemical Corporation, where small size sample electrodes have been made showing satisfactory electrical properties. At the Chalmette plant, full-scale pot tests have been made using blends of calcined fluid coke in the Soderberg electrodes with encouraging results. It is felt that at the present time as much as 30 percent of the fluid coke can be used in a blend with the conventional calcined delayed coke, as limited by size distribution, provided the other properties of the fluid coke, such as sulfur and metals content, are acceptable. Further development work currently under way with fluid coke undoubtedly will increase the allowable percentage which can be used.

Many other uses have been suggested for fluid coke, including applications in the manufacture of calcium carbide, phosphorous, and carbon disulfide. In the field of metallurgy there are many purposes to which it might be put. Undoubtedly in some instances the coke would require pelletizing or briquetting before it could be brought to its end use. Fluid coke however is a material almost as new to the refiner as it is to the user, and its full potential will be brought out only after the research and development work now under way by many interested groups becomes known.

This is a condensation of a paper presented before the Southwest Regional Meeting of the Western Petroleum Refiners Association in El Paso, Texas, May 23-24, 1957.

TABLE 4—Properties of Typical Calcined Electrolytic Grade Petroleum Coke (Delayed Process) Used for Soderberg Anodes

COMPOSITION	Percent
Volatile	0.05
Ash	0.35
Silicon	0.02
Iron	0.03
Sulfur	1.10
Other Metallics	0.03
Real Density, g/cc	2.05

SCREEN ANALYSIS	Percent
+4	5.6
−4+8	11.8
−8+14	13.7
−14+28	12.4
−28+48	9.0
−48+100	11.2
−100+200	11.9
−200	24.4
	100.0

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About the Author

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Octane Number*	F-1 (Research)		F-2 (Motor)		Road**
TEL Content, cc/gal	0	3	0	3	3
Isopentane Fraction	92	106	90	108	110
Alkylate	93	105	91	106	109
95 Octane Reformate	95	101	85	92	102
Total Isomer	81	96	81	97	100
Propylene Polymer	94	99	81	85	98
Cat Cracked Gasoline	93	99	81	86	98
Isohexane Fraction	68	90	68	87	93
Virgin Light Naphtha	65	86	65	86	90
Thermal Reformate	74	87	69	79	88
Thermally Cracked	70	85	66	76	85

* Octane numbers over 100 by the Wiese formula, $ON = 100 + \frac{PN-100}{3}$

** Modified Borderline Method at 2,000 rpm estimated by: Road = 3.5 + 0.65 (F-1) + 0.35 (F-2).

Isom Process Gives High Road Octanes

High octane motor fuels can be obtained by isomerizing pentanes and hexanes with the new Iso-Kel process. Here are data on laboratory and road ratings of the isomerized products.

E. F. Schwarzenbek
The M. W. Kellogg Company
Jersey City, N. J.

EXAMINATION OF the octane qualities of a number of the potential components of the gasoline pool shows that light naphtha is one of the lowest quality components of the pool. The very lowest octane components of the pool, thermal reformate and thermally cracked gasoline, are gradually being eliminated by the installation of catalytic reforming and catalytic cracking processes.

The octane increases over the past years have been attributable primarily to this replacement of thermal gasolines by catalytically produced gasolines. The octane increase in the future will result from the installation of increased alkylation capacity, by the use of more severe catalytic reforming techniques, and by pentane-hexane isomerization.

Although the alkylation and severe reforming techniques will be employed to upgrade the main body of the gaso-

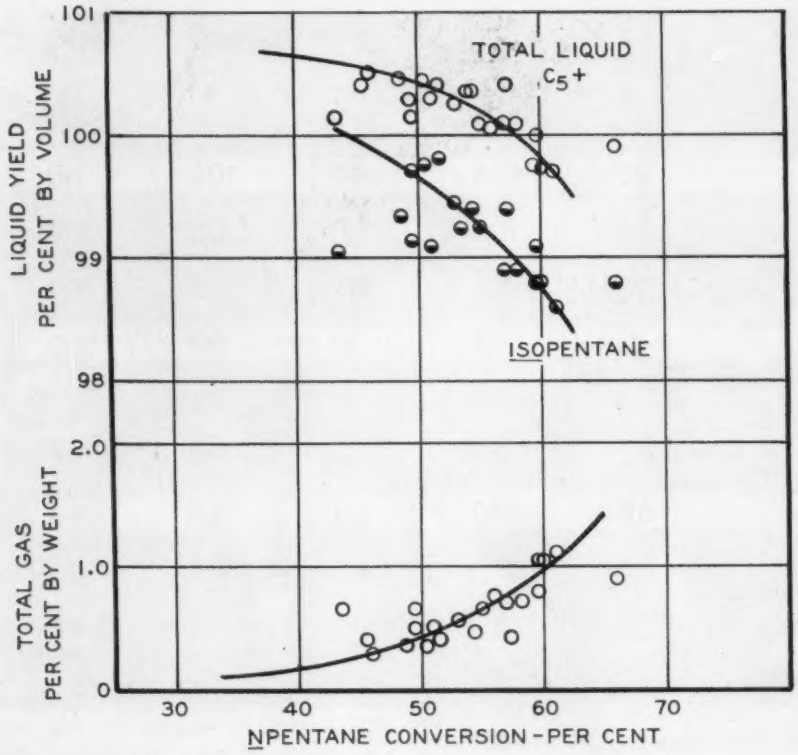


FIGURE 1—Under the conditions employed, the conversion of *n*-pentane to *iso*-pentane was limited by thermodynamic equilibrium to approximately 65 to 69.

TABLE 1—nPentane Isomerization

Yield Basis	Single Pass	Ultimate
Conversion per pass	60	
Percent by Weight		
Methane	0.1	0.1
Ethane	0.1	0.2
Propane	0.3	0.4
Percent by Volume		
Butanes	0.1	0.2
*Iso*pentane	59.3	98.7
*n*Pentane	40.0	....
Cyclopentane	0.6	1.1
C_6+ liquid	0.0	0.0
Total C_5+ liquid	99.9	99.8
Total C_4+ liquid	100.0	100.0

TABLE 2—nHexane Isomerization

Yield Basis	Singel Pass	Ultimate
Conversion per pass	75	
Percent by Weight		
Methane	0.1	0.1
Ethane	0.1	0.2
Propane	1.8	2.4
Percent by Volume		
Butane	0.6	0.7
*Iso*pentane	0.6	0.8
*n*Pentane	0.6	0.7
2,2-Dimethylbutane	8.2	11.0
2,3-Dimethylbutane	6.9	9.2
2-Methylpentane	31.7	42.3
3-Methylpentane	22.4	29.9
*n*Hexane	25.0	....
Methylcyclopentane	1.8	2.4
Cyclohexane	0.3	0.4
Benzene	0.0	0.0
Total C_5+ liquid	97.5	96.7

line pool, our studies indicate that attention must also be directed to upgrading some of the lower octane quality components of the pool—petroleum light naptha and natural gasoline.

These two materials are necessary compounds inasmuch as they have the important function of giving the gasoline pool a balanced volatility. However, typical light naphtha with three ml TEL per gal is about seven Research octane numbers lower in quality than the present day gasoline pool. It is apparent that as octane demand increases, upgrading of light naphtha will be required if the lighter components are not to be a drag on pool quality.

This anticipated demand for the upgrading of light petroleum hydrocarbons was the incentive that led to the development, by The M. W. Kellogg Company, of the Iso-Kel isomerization process. This process produces at least two product streams, an *iso*pentane stream and an *iso*hexane-rich stream. Typical qualities of these streams, and of the total Iso-Kel product, are included in the lead table, along with those of the other potential components of the gasoline pool. An attempt has been made to give each gasoline component a *relative* road octane rating. This rating has been based on recent experience with five high-compression-ratio cars where it has been found that the modified borderline road rating at 2,000 rpm can be equated to 3.5 plus 0.65 times the Research rating plus 0.35 times the Motor rating. At lower speeds more emphasis should be given to Research rating, whereas at higher speeds emphasis should be on Motor rating. The trend in present engine design is such that high-speed performance is becoming increasingly important, with the result that fuels of lower sensitivity show better overall road performance.

It should be noted that the isomerized products are similar to alkylate in that their Motor and Research octane ratings are essentially equivalent. Their road performances are better than expected when comparing them with fuels, such as catalytically cracked gasoline or catalytic reformate on the basis of Research ratings alone. The *iso*pentane fraction rates with alkylate as a top octane component of future premium gasolines. The combined pentanes and hexanes in light naphtha can be upgraded by isomerization to a road performance quality similar to catalytic polymer, catalytically cracked gasoline, and 95 clear octane catalytic reformate. Road performance results for Iso-Kel products are discussed in more detail later in the paper.

Octane Quality. Light naphtha and natural gasoline contain high percentages of material in the pentane-hexane boiling range. The low octane quality of this fraction is attributable primarily to the presence of *n*pentane and *n*hexane which rate, with three ml TEL per gal, 89 and 65, respectively. The isomers of these compounds have octane numbers 20 to 54 numbers higher than the corresponding normal compound, having ratings with three ml TEL between 93 and 119. The napthenes, cyclohexane and methylcyclopentane, normally present in these fractions also have high octane quality, rating with three ml

TEL, 97 and 105, respectively. The conversion of the normal compounds to their corresponding isomers materially increases the octane quality of petroleum light naphtha and natural gasoline.

Pentane-Hexane Isomerization. Extensive catalyst development work was therefore carried out, and as a result a new catalyst was discovered. The Iso-Kel process employs a precious metal catalyst (nonplatinum) which has been specifically prepared to give long life without regeneration and high isomerization activity with negligible cracking side reactions. This catalyst has been studied over the following range of conditions:

Temperature, deg F	700- 850
Pressure, psi	100- 750
Recycle Gas, cu ft per bbl	1500-6000

In general, the process is operated in the same pressure range as conventional catalytic reforming, but at lower gas recycle rates and higher space velocities.

The catalyst is highly active permitting operation at temperatures considerably below those normally employed in conventional heavy naphtha reforming operations. The high selectivity of the catalyst is illustrated in Figure 1 where ultimate yields of dry gas, *iso*pentane, and C_5+ liquid are related to extent of conversion per pass of *n*pentane to *iso*pentane. Under the conditions employed the conversion of *n*pentane to *iso*pentane was limited by thermodynamic equilibrium to approximately 65 to 69. As thermodynamic equilibrium was approached, cracking side reactions increased markedly. A conversion limit of about 60 percent is therefore usually recommended. A more detailed breakdown of the products at this level is presented in Table 1. At 60 percent conversion per pass the ultimate gas production is only 0.9 percent by weight, the ultimate *iso*pentane yield being 98.7 percent by volume, and the ultimate C_5+ liquid yield 99.8 percent by volume.

Iso-Kel catalyst is also efficient for the isomerization of *n*hexane to its corresponding isomers. With *n*hexane the conversion per pass is higher than with *n*pentane, inasmuch as conversion is limited by thermodynamic equilibrium to approximately 76 percent to 79 percent as compared to about 67 percent for *n*pentane isomerization. Typical data are presented in Table 2. At 75 percent conversion per pass the data show an ultimate gas production of 3.4 percent by weight and a C_5+ yield of 96.7 percent by volume. It will be observed from the data that the catalyst produces both the dimethyl and monomethyl isomers of hexane, the ratio of dimethylbutanes to monomethylpentanes being approximately 1:3.5. The Research octane-number quality of *n*hexane can be increased from 65 to approximately 96 with the addition of three ml TEL by recycling *n*hexane only.

TABLE 3—Composition of Typical Pentane-Hexane Fractions

SOURCE	PERCENT BY VOLUME			
	Kuwait	Mid-Continent	Natural Gasoline	Light Reformate
*Iso*pentane	17.4	12.6	32.2	21.7
*n*Pentane	24.6	21.9	24.2	17.3
Cyclopentane	0.1	0.3	0.9	0.7
2,2-Dimethylbutane	1.1	0.3	1.3	2.6
2,3-Dimethylbutane	2.2	0.3	1.3	3.0
2-Methylpentane	11.8	17.1	13.0	16.7
3-Methylpentane	8.9	9.3	5.0	12.8
*n*Hexane	22.8	27.1	10.8	14.9
Methylcyclopentane	2.7	9.1	6.8	1.2
2,2-Dimethylpentane	1.1	0.1	1.5	0.7
Benezene	1.1	0.4	0.0	7.1
2,4-Dimethylpentane	4.0	0.1	1.2	1.3
Cyclohexane	2.2	1.4	1.8	0.0
*n*Paraffin content, percent				
Pentane fraction	58.6	63.5	42.9	44.3
Hexane fraction	48.7	50.1	34.4	29.8
ASTM Octane Number (D 908, Research Method):				
Without TEL addition	64.1	63.0	73.0	71.2
With 3 ml TEL per gallon	88.2	86.5	93.4	91.2

Isomerization of Typical Feeds. Materials boiling in the pentane-hexane range can be readily processed in a single reactor. *n*Pentane may be economically recycled and converted to *iso*pentane. Inasmuch as the materials boiling in the hexane range have much closer boiling points (see accompanying box) it is more economical to process the hexane fraction on a once-through basis. This is particularly true if the feed stock contains considerable percentages of methylcyclopentane. Thermodynamic equilibrium limits the conversion of methylcyclopentane to cyclohexane to approximately 12 percent compared to approximately 77 percent for the conversion of *n*hexane to its isomers.

Methylcyclopentane is difficult to separate from *n*hexane by distillation. Therefore with feeds having a high percentage of methylcyclopentane, recycle rate will be high and single pass operation is recommended. If the methylcyclopentane content is low, methylcyclopentane and *n*hexane can be recycled together to extinction.

The composition of pentane-hexane fractions from two petroleum light naphthas, a natural gasoline and a catalytic reformate, are presented in Table 3. These feed stocks range in Research octane quality from 88 to 93 with three ml TEL. It will also be noted that there is considerable variation in the amount of *n*paraffins, naphthenes, and aromatics in these feeds. Different methods of processing these feeds would, therefore, be employed.

Because the natural gasoline and the light reformate have a higher *iso*hexane-*n*hexane ratio than the two petroleum light naphthas, a deisohexanizer would be recommended in the processing of these feeds. Kuwait light naphtha and light reformate are low in methylcyclopentane content, and recycling of *n*hexane to extinction could be practiced. The Mid-Continent light naphtha and the natural gasoline, on the other hand, are high in methylcyclopentane content, and single pass operation for such feeds is recommended.

The effect on yield and quality of alternate methods of processing the

TABLE 4—Alternate Methods of Processing Kuwait Hexane Fraction

Process Method	Yield-Volume (Percent)	ASTM Octane Number (D 908, Research Method) With 3 ml TEL per Gal.
Feed	100.0	82.0
Once-through	98.0	89.0
Once-through with deisohexanizer	99.1	91.3
Recycling with deisohexanizer	97.7	93.7

hexane fraction from Kuwait light naphtha is presented in Table 4. Once-through isomerization increases the octane quality from 82 to 89 with three ml TEL. By the addition of deisohexanizing facilities, quality can be raised to 91 with three ml TEL. Recycling of *n*hexane and methylcyclopentane to extinction will result in a further increase to approximately 94 with three ml TEL. Raising the octane number above 94 can be effected by recycling a part or all of the methylpentanes.

The results of the Iso-Kel isomerization of the feeds shown in Table 3 are presented in Table 5. Processing of these feeds produces at least two separate products, an *iso*pentane stream with an octane of 105 with three ml TEL and a combined *iso*hexane stream with octane numbers ranging between 89 and 94 with three ml TEL depending on feed stock composition (see Table 4). The overall processing of these feed stocks results in yields of 98 percent to 99 percent by volume and octane numbers of 95 to 100 with three ml TEL.

TABLE 5—Isomerization of Commercial Feed Stocks

	Kuwait*		Mid-Continent*		Natural Gasoline†		Light Reformate†	
	Feed	Product	Feed	Product	Feed	Product	Feed	Product
Total C_5 to C_6								
Volume, percent	100.0	98.6	100.0	98.3	100.0	99.2	100.0	99.3
ASTM Octane Number (D 908, Research Method):								
Without TEL addition	64.1	79.0	63.0	78.0	73.0	85.7	71.2	82.4
With 3 ml TEL per gal.	88.2	96.0	86.5	95.0	93.4	99.6	91.2	96.7
***Iso*pentane Fraction**								
Volume, percent	45.0	45.0	34.5	34.5	58.5	58.5	38.5	38.5
ASTM Octane Number (D 908, Research Method):								
Without TEL addition	74.4	92.0	72.9	92.0	79.2	92.0	78.2	92.0
With 3 ml TEL per gal.	95.8	105.6	94.5	105.6	98.0	105.6	95.8	105.6
***Iso*hexane Fraction**								
Volume, percent	55.0	53.6	65.5	63.8	41.5	40.7	61.5	60.8
ASTM Octane Number (D 908, Research Method):								
Without TEL addition	55.9	68.0	57.7	70.5	64.0	76.4	66.8	76.4
With 3 ml TEL per gal.	82.0	89.0	82.3	90.0	86.8	93.5	88.3	92.0

* Recycle of *n*pentane and once-through on hexanes.
† Deisohexanizing facilities included.

TABLE 6—Economics of Isomerization of Kuwait Pentanes and Hexanes

CASE	I*	II†	III‡	IV§
ASTM Octane Number+ (D 908, Research Method):				
Without TEL addition	90.9	79.0	79.8	90.9
With 3 ml TEL per gallon	102.9	96.0	96.7	102.9
Capacity, barrels per day	1,495	3,100	3,100	3,500
Process investment	$825,000	$1,100,000	$1,425,000	$1,475,000
Direct operating cost, cents per barrel	24	16	22	21
Payout, years	1.4	1.4	1.8	1.0
Cost, cents per Research octane-number barrel‖	10.6	7.6	8.4	9.6

* Recycle isomerization of *n*pentane cut containing 7.0 percent by volume hexanes.
† Isomerization of mixed pentane-hexane, recycle operation on the *n*pentane, once-through on the *n*hexane. No deisohexanizer (Fig. 2).
‡ Same as Case II but including deisohexanizer.
§ Same as Case I but at increased throughput.

+ Octane numbers above 100 by the Wiese formula, octane number $= 100 + \frac{PN - 100}{3}$

‖ Cents per Research octane-number barrel based on 93 Research octane number with 3 ml TEL pool gasoline.

TABLE 7—Road Performance Data—Effect of Light Naphtha Isomerization

BLEND COMPONENTS

	OCTANE NUMBER*			
	ASTM D 357 (Motor Method)		ASTM D 908 (Research Method)	
	Without TEL Addition	With 3 ml TEL Per Gal.	Without TEL Addition	With 3 ml TEL Per Gal.
Light naphtha, C_5 and C_6	66.0	86.3	66.4	85.9
Iso-Kel, C_5 and C_6	80.2	96.2	81.1	96.2
Alkylate	91.0	106.2	93.0	104.7
Dehexanized reformate "A"	68.7	83.0	73.5	90.1
Dehexanized reformate "B"	85.4	90.5	96.6	101.1
Dehexanized reformate "C"	95.8	100.0	104.4	106.5

GASOLINE BLENDS

Blend Number	1	2	3	4	5	6
Composition, percent by Weight†						
Light naphtha	40	40	40	....	....	....
Iso-Kel product	....	....	....	40	40	40
Alkylate	20	20	20	20	20	20
Reformate "A"	40	....	....	40	....	....
Reformate "B"	....	40	....	....	40	....
Reformate "C"	....	....	40	....	....	40
Octane-number Blends, 10-lb RVP						
ASTM D 357 (Motor Method) With 3 ml TEL per gallon	89.2	92.4	93.6	92.5	96.4	97.0
ASTM D 908 (Research Method)* With 3 ml TEL per gallon	91.8	96.4	98.8	95.2	99.8	102.5
Road Octane* With 3 ml TEL (Average at 2000 rpm, 2500 rpm, 3000 rpm)	93.9	99.2	100.0	97.5	102.6	104.2

* Octane numbers above 100 by the Wiese formula, octane number $= 100 + \frac{PN - 100}{3}$.
† Before addition of butane to 10-lb RVP.

Catalyst Properties. The catalyst is employed in the form of 1/16 inch extrudates, and has, in general, the same physical properties as some platinum reforming catalysts. A number of long cycle operations and accelerated aging tests have been carried out. On the basis of these tests, long catalyst life without regeneration is indicated. The catalyst, however, has been regenerated and satisfactory recovery experienced.

Generally, the catalyst is subject to the same poisons as platnium reforming catalysts. Sulfur, in particular, has an adverse effect on catalyst life and desulfurization of the feed stock to a low level is recommended.

Economics. Process investments and operating costs are presented in Table 6 for a number of possible flow schemes for the isomerization of pentanes and hexanes from Kuwait crude oil:

Case I—A pentane isomerization unit with a capacity of 1495 barrels per day has a process investment of approximately $825,000 and a payout of 1.4 years before taxes.

Case II—Inclusion of the hexane fraction will increase the capacity to 3100 barrels per day. Then processing the pentanes on a recycle basis and the hexanes on a once-through basis will result in an investment of $1.1 million and a payout the same as Case I (1.4 years).

Case III—Including a deisohexanizer in the process scheme increases the payout to 1.8 years. However, the octane quality of the *iso*hexane product is increased by two numbers.

Case IV—Increasing the capacity of pentane-isomerization unit from 1495 to 3500 barrels per day decreases the payout from 1.4 years to 1.0 years.

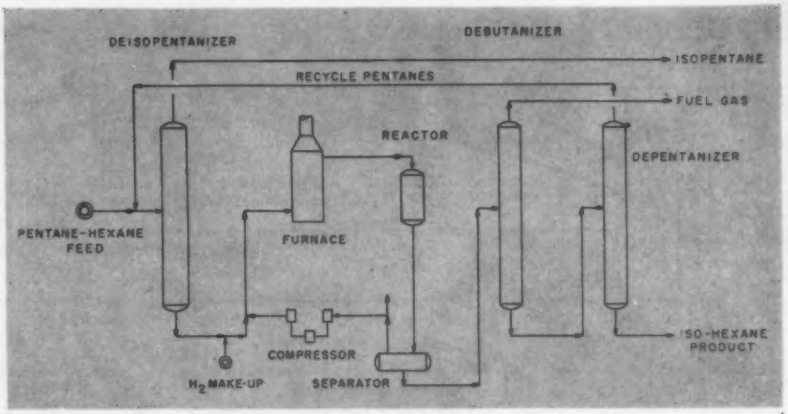
The process investments in Table 6 do not include desulfurization facilities or investment for catalyst inventory. Catalyst makeup costs are included with labor and utilities in the direct operating costs, which vary between 16 and 24 cents per barrel.

In determining payouts, values were assigned to feed and isomer products based on the Gulf Coast bulk price of gasoline as a function of Research octane number. Catalyst investment costs were considered as an interest charge.

Costs were also expressed as cents per Research octane number barrel by the method developed by the Ethyl Corporation. These costs based on a 93 Research octane number with the addition of three ml TEL pool gasoline varied between 7.6 and 10.6 cents per Research octane-number barrel. Our studies show these costs to be lower than would be calculated for increasing octane quality by severe reforming techniques.

Road Performance Tests. In order to obtain some information on the road performance of isomerized pentanes and hexanes, a cooperative program on the antiknock performance of a variety of high-octane-quality gasoline blends has been carried out by The M. W. Kellogg Company and the Ethyl Corporation. Five cars of different makes, with automatic transmissions, with compression ratios between 9.5 and 11, and with octane demands between 91 and 100, were employed in these tests.

Two series of three gasoline blends were prepared to determine the improvement in road performance to be expected on substituting isomerized product for virgin light naphtha. The quality of the components, and quality and composition of the finished blends are shown in Table 7. These data are presented graphically in Figure 2 in which the Research octane number with three ml TEL of the dehexanized reformate used in the blend is plotted against the Modified Borderline Method octane number with three ml TEL (averaged for speeds of 2000 rpm, 2500 rpm, and 3000 rpm). Two important conclusions can be drawn:



Here's the flow diagram for the process:

Here is a typical flow diagram for the Iso-Kel processing of a desulfurized petroleum light naphtha. Recycling of the unconverted *n*pentane and once-through isomerization of the hexane fraction is practiced. The mixed pentane-hexane feed is charged to a deisopentanizer, where it is joined by the pentane isomerization product. The *n*pentane and total hexane bottoms from the deisopentanizer are fed to the reactor with makeup hydrogen and hydrogen-rich recycle gas.

Hydrogen consumption caused by hydrocracking is very low, and only a small quantity of makeup hydrogen is necessary. The products from the reactor flow to a separator, and the liquid is then debutanized and depentanized for recycling of the *n*pentane to extinction. This processing scheme results in an *iso*pentane stream and a once-through hexane stream.

Further upgrading of the hexane fraction can be achieved by the addition of deisohexanizing facilities. This is particularly recommended when the *iso*hexane content of the feed hexane fraction is high. This method of processing produces three product streams: high-purity *iso*pentane, virgin *iso*hexanes, and an *iso*hexane-rich isomerization product.

1. To attain a given road octane number of the blend, the octane quality of the dehexanized reformate can be considerably reduced (nine numbers in this study) by isomerizing the light naphtha before blending in the pool. A concomitant advantage of higher pool yield is realized because of the higher yield when reforming at the lower octane level, and,

2. At a given reformate octane number, the pool octane can be raised significantly (3.5 numbers in this comparison) by isomerization of the light naphtha.

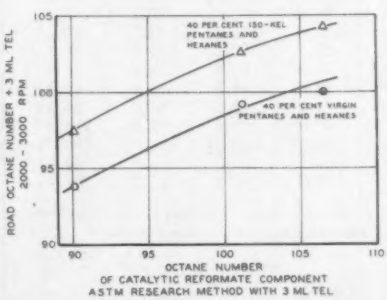


FIGURE 2—Here is the improvement in road performance to be expected when substituting isomerized product for virgin naphtha.

There is a significant incentive for considering isomerization before decisions are made on very severe catalytic reforming of virgin heavy naphtha or the upgrading of heavy catalytically cracked gasoline.

The effect of engine speed on the road rating of a typical blend containing isomerized pentanes and hexanes is illustrated in Figure 3. Included in this chart are the results obtained with a blend in which a pentane-hexane cut from catalytically cracked gasoline was substituted for the pentane-hexane paraffin isomers. The composition and qualities of these blends is presented in Table 8. The pentane-hexane fraction had a Research octane number of 96.2 with three ml TEL. The particular cracked pentane-hexane fraction used had a

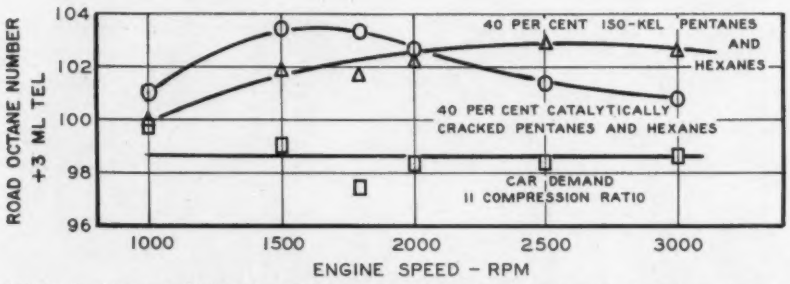


FIGURE 3—At speeds higher than 2000 rpm, the blends containing isomerized products showed better road performance.

TABLE 8—Road Performance Data—Comparison of *Isoparaffin* and Olefin Blends

	Car Demand*	Iso-Kel	Catalytic Cracked
Pentane-Hexane Component			
ASTM Octane Number (D 908, Research Method): With 3 ml TEL per gallon	....	96.2	100.4
ASTM Octane Number (D 357, Motor Method): With 3 ml TEL per gallon	....	96.2	87.7
Blend Composition (butane free)			
Iso-Kel pentanes and hexanes	....	40	....
Cracked pentanes and hexanes	....	....	40
Alkylate	....	20	20
Dehexanized reformate "B"	....	40	40
Octane Number Blends,† 10-lb RVP			
ASTM (D 908, Research Method): With 3 ml TEL per gallon	....	99.8	102.5
ASTM (D 357, Motor Method): With 3 ml TEL per gallon	....	96.4	92.4
Road Octane‡			
With 3 ml TEL			
1000 rpm (2-car average)	99.7	99.8	101.1
1500 rpm (3-car average)	99.0	101.9	103.4
1800 rpm (1-car)	97.5	101.7	103.4
2000 rpm (5-car average)	98.3	102.3	102.6
2500 rpm (5-car average)	98.4	102.8	101.4
3000 rpm (5-car average)	98.6	102.6	100.8

* Demand for 11 compression-ratio cars, primary reference fuels.

† Octane numbers above 100 by the Wiese formula, octane number $= 100 + \frac{PN - 100}{3}$

‡ Modified Borderline rating.

Compare Low Octane Normal Paraffin with Other Compounds Boiling in this Same Range

Compound	Boiling Point (Degree Fahrenheit)	F-1 (Research) Octane* Without TEL	F-1 (Research) Octane* 3 ml TEL per Gal.	F-2 (Motor) Octane* Without TEL	F-2 (Motor) Octane* 3 ml TEL per Gal.
*Iso*pentane	82.1	92.3	108.5	90.3	109.3
***n*Pentane**	**96.9**	**61.7**	**88.7**	**61.9**	**83.6**
Cyclopentane	120.6	101.7†	105.9†	85.0	95.2
2,2-Dimethylbutane	121.5	91.8	106.0	93.4	113.1
2,3-Dimethylbutane	136.4	103.6	119.1†	94.3	112.2
2-Methylpentane	140.5	73.4	93.1	73.5	91.1
3-Methylpentane	145.9	74.5	93.4	74.3	91.3
***n*Hexane**	**155.7**	**24.8**	**65.3**	**26.0**	**65.2**
Methylcyclopentane	161.3	91.3	105.2	80.0	93.0
2,2-Dimethylpentane	174.6	92.8	104.4	95.6	114.0
Benzene‡	176.2	98.0†	106.0†	94.0†	120.0†
2,4-Dimethylpentane	176.9	83.1	96.6	83.8	99.1
Cyclohexane	177.3	83.0	97.4	77.2	87.3

* Octane numbers above 100 by the Wiese formula, octane number $= 100 + \frac{PN - 100}{3}$

† Determined by The M. W. Kellogg, all other API Project 45.

‡ Octane numbers in 10 percent benzene and 90 percent hexane blends.

Research octane number of 100.4 with three ml TEL.

The blend containing the light catalytically cracked gasoline showed the best road performance at low engine speeds. However, at speeds higher than 2000 rpm, the blend containing isomerized pentanes and hexanes showed better road performance even though the Research rating of the blend was not as high. It should be noted that the blend containing the pentane and hexane isomers had higher road ratings than its Research octane rating. The blend containing the catalytically cracked pentanes and hexanes, on the other hand, depreciated in road rating at very low and very high speeds. It is obvious that consideration of only Research octane number of the pool gasoline can be misleading when estimating the performance of gasoline on the road.

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ACKNOWLEDGMENT

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About the Author

E. F. SCHWARZENBEK graduated from Massachusetts Institute of Technology in 1935 with a B.S. degree in chemical engineering. The same year he joined E. I. duPont de Nemours and Company, Inc., as a research engineer. In 1937 he began his service with The M. W. Kellogg Company as a research chemical engineer. He became associate director of the laboratory in 1946, succeeding to his present position of director of the laboratory in 1949.

Data on Latest Reforming Process

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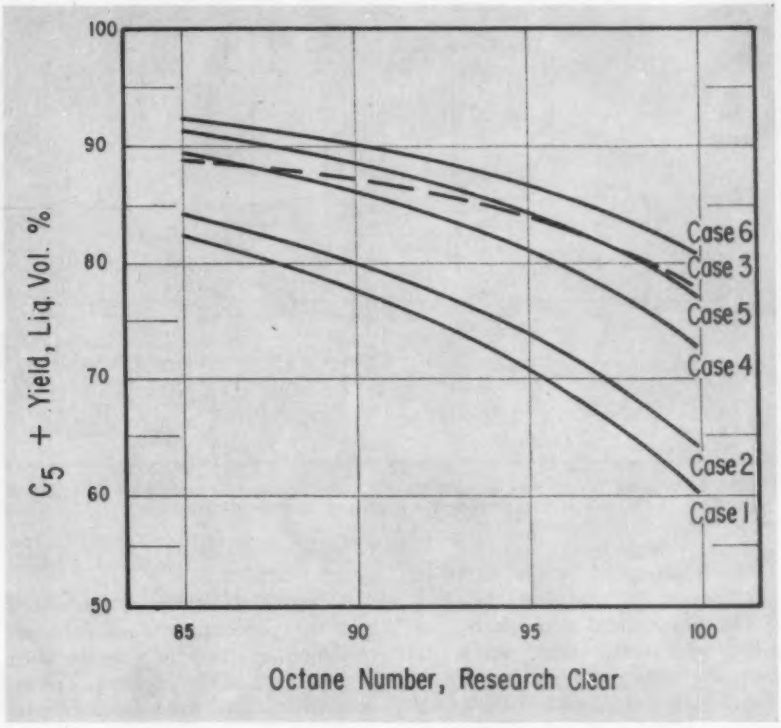

FIGURE 1—The cases shown here are identified in Table 1.

THE BATTLE for higher octane motor fuels brought a number of advancements in reforming catalyst and processing techniques. The most recent reforming process is Esso Research and Engineering Company's Powerforming. Although the process was not announced formally until March of last year, two units have been on stream for over two years.

Powerforming is a fixed-bed catalytic process using a platinum catalyst. The catalyst is regenerated periodically by a technique which is capable of maintaining very high activity. Here is a summary of what this new process can do.

Upgrading low octane naphthas to high octane motor gasoline components, the process can make product of from 85 to over 100 Research octane number clear. Alternatively, the process may be operated to produce aviation blending stocks or to give high yields of aromatics. A large amount of hydrogen is obtained as by-product.

Typical feed stocks consist of naphthas in the boiling range from 160 to 400 F. The product quality and yields at 100 Research octane number clear for five different feed stocks is given in Table 1.

If a product of lower octane is satisfactory, the yield will be much greater. The effect of octane level on the yield of debutanized liquid is shown in Figure 1.

How the Process Works. A flow plan illustrating the operation of a Powerformer is shown in Figure 2. The naphtha feed is desulfurized in a Hydrofiner using hydrogen treat gas

TABLE 1—Feed Stocks and Product Yield

FEED SOURCES	Case 1 Arabian	Case 2[1] Arabian	Case 3[1] Arabian	Case 4 Red-water	Case 5 Mixed La.	Case 6 W. Texas
Nominal cut range, °F	160/260	150/300	300/385	170/310	200/330	200/300
Feed Properties						
Gravity, °API	64.7	61.6	49.6	57.2	55.0	53.0
Research O.N. clear	44	42	26	58	58	56
ASTM 5% point, °F	199	190	310	220	223	235
ASTM 50% point, °F	217	236	342	241	253	260
ASTM 95% point, °F	249	294	380	288	304	291
Watson K Factor	12.2	12.1	11.9	11.9	11.8	11.7
Yields, Percent on Feed						
C_5 plus, Volume Percent	60.1	64.3	78.3	73.5	77.5	81.0
H_2, Weight Percent	1.6	1.3	1.3	2.4	2.1	2.0
C_1, Weight Percent	2.9	2.3	1.3	2.1	1.7	1.5
C_2, Weight Percent	7.0	5.9	2.8	3.7	2.9	2.5
C_3, Weight Percent	11.1	10.0	5.7	8.2	5.1	4.4
C_4, Volume Percent	17.0	15.0	8.4	10.7	8.8	7.8
C_5 Plus Powerformate Properties						
Volatility, Percent D Plus L @						
158° F	27	22	2	9	4	5
212° F	62	50	16	43	29	21
257° F	85	73	29	66	60	59
302° F	94	90	45	89	84	85
356° F	98	97	74	97	96	98
ASTM Final B. Pt. °F	381	392	444[2]	396	402	385
Gravity, °API	53.0	49.0	40.0	47.5	45.9	44.3
RVP, psi	7.6	7.5	2.7	4.5	4.0	3.5
Octane Numbers						
Research Clear	100	100	100	100	100	100
Research + 3cc TEL	105.6	105.6	105.6	105.6	105.6	105.6
Motor Clear	88.6	88.6	88.6	88.6	88.6	88.6
Motor + 3cc TEL	94.8	94.6	93.2	93.6	93.1	93.1

[1] An Arabian 160/385 split into two fractions for running in blocked operation in Case 2 and 3.
[2] Before rerunning.

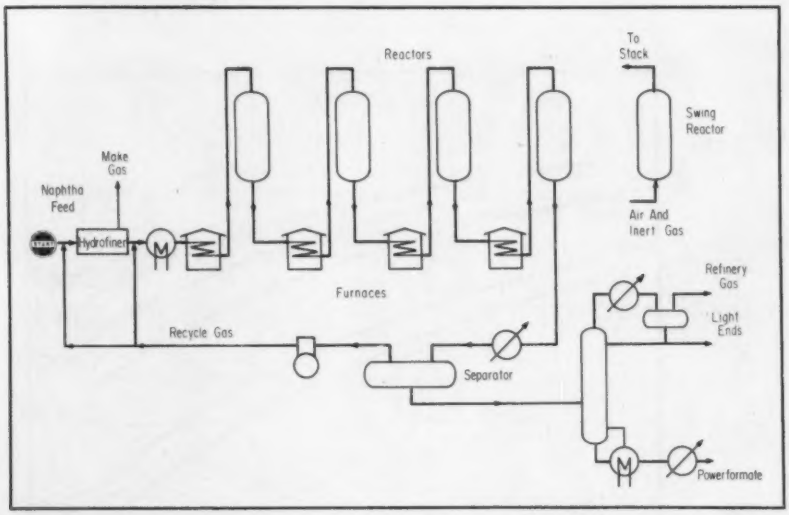

FIGURE 2—A swing reactor may be used so that catalyst activity is maintained by regeneration without reducing the number of reactors on-stream.

About the Author

P. H. HOLT II, is manager of Esso Research and Engineering Company's Process Licensing unit, which is responsible for licensing petroleum and petrochemical processes. He has been with the company since 1937, and holds B.S. and M.S. degrees in chemical engineering from Massachusetts Institute of Technology.

which is produced by the reforming reactions.

The desulfurized naphtha is combined with compressed recycle gas from the separator drum and enters the first reactor after absorbing heat from exchange with effluent from the last reforming reactor and from a preheat furnace.

Because the reactors are adiabatic and the predominant reactions are endothermic, there is a temperature drop in each of the reactors. The reaction products from number one, two, and three reactors are reheated to maintain the necessary reaction temperature. The effluent from the last reactor provides preheat for the feed to the first reactor. After further cooling, the gas and liquid products are separated in the separator drum.

The product from the separator drum is stabilized (and rerun, if necessary) in conventional equipment. Hydrogen from the separator is used as treat gas in the treating of the charge or other products.

When a swing reactor is used, catalyst activity is maintained by regeneration without taking the unit off-stream. If no swing reactor is employed, the unit is taken off-stream for catalyst regeneration. The usual operating conditions are given in Table 2.

TABLE 2
Usual Operating Conditions

Average pressure, psig	300—450
Reactor inlet temperature, °F.	900—1000
Recycle Gas Rate, SCF/Bbl.	4000—6000
Space Velocity W/Hr/W	1–4

The Catalyst used for Powerforming consists of platinum on a supporting base prepared by a special process. An improved regeneration technique contributes significantly to the high activity and long life of the catalyst. In addition to performing the traditional task of removing carbon and sulfur compounds which cause temporary catalyst deactivation, the new regeneration technique overcomes a somewhat more permanent deactivation which occurs, probably due to physical and physiochemical changes. Regeneration essentially restores the original activity and selectivity.

In a typical unit, the catalyst regeneration facilities are designed to regenerate the catalyst in a reactor in 16 to 24 hours. In a unit having four reactors on-oil and one swing reactor, the entire catalyst charge (including the swing reactor) could, if necessary, be regenerated every 80 to 120 hours. When included in the design, the swing reactor is used to replace each on-oil reactor as the catalyst is regenerated. ##

Where Powerforming Units are Operating, Building, or Approved

COMPANY	Location	Capacity B/SD	Research O.N. (Clear)	Unit Type	Startup Date
Esso Std. Oil Co.	Baltimore, Md.	3,000	92	Non-Regen.	July 1955
Imperial Oil, Ltd	Edmonton, Alta.	2,200	85	Non-Regen.	Aug. 1955
Carter Oil Co.	Billings, Mont.	2,500	85	Semi-Regen.	Feb. 1956
Imperial Oil, Ltd	Sarnia, Ont.	15,000	95	Semi-Regen.	Dec. 1956
Imperial Oil, Ltd	Halifax, N.S.	7,000	95	Cyclic	(1957)
Imperial Oil, Ltd	Montreal, Que.	9,000	95	Cyclic	(1957)
*Raffineria Garrone	Genoa, Italy	5,600	95	Cyclic	(1957)
*RASIOM	Augusta, Sicily	7,300	100	Cyclic	(1957)
*International Refineries, Inc.	Wrenshall, Minn.	2,800	95	Semi-Regen.	(1957)
Esso Std. Oil Co.	Linden, N. J.	20,000	98	Cyclic	(1957)
Esso Std. Oil Co.	Everett, Mass.	7,200	98	Semi-Regen.	(1957)
STANIC	Bari, Italy	7,300	100	Cyclic	(1957)
Imperial Oil, Ltd	Loco, Brit. Col.	4,000	95	Cyclic	(1957)
Esso Italiana	Trieste, Italy	1,000	91	Semi-Regen.	(1957)
Esso Std. Oil, S.A.	Belot, Cuba	2,500	85/95	Semi-Regen.	(1957)
Esso Std. Oil Co.	Baton Rouge, La.	26,900	100.5	Cyclic	(1957)
Esso Std. Soc. An Fr.	Port Jerome, Fr.	14,500	98/100	Cyclic	(1958)
Esso Std. Refinery, S.A.	Antwerp, Belgium	5,600	95	Cyclic	(1958)
*Cie. Francaise de Raffinage	La Mede, France	20,000	98	Cyclic	(1958)
Esso A. G.	Cologne, Germany	9,000	100	Cyclic	(1959)
Esso Std. Soc. An. Fr.	Bordeaux, France	8,000	100	Cyclic	(1959)

* Licensees.

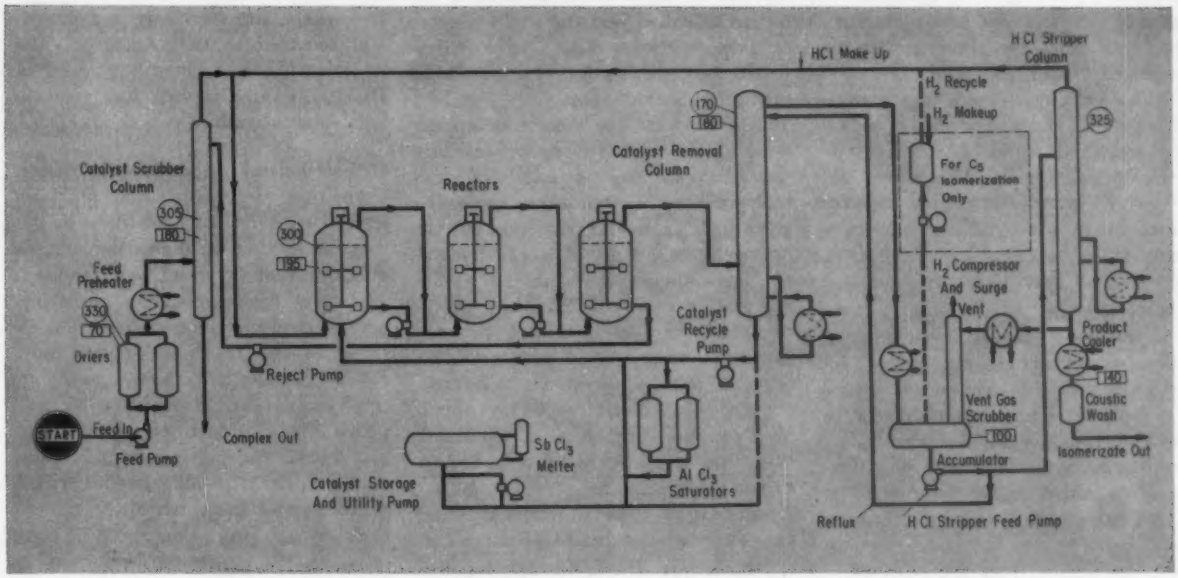

FIGURE 1—This new design provides three reactors in series to achieve a closer approach to equilibrium.

The New Look in Butane Isomerization

Here are the changes Shell made in their liquid-phase isomerization process. It can be adapted to pentane isomerization too.

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THE INCREASING DEMAND for aviation gasoline over the years and now the increasing demand for motor fuels of progressively higher octane rating have forced the refiner to develop new refining techniques and to make broader use of existing ones. Prominent among the latter is olefin alkylation with isobutane. The product made by this process is a saturated branched hydrocarbon of high neat octane rating, low sensitivity, high lead susceptibility, and generally excellent blending properties. In past years, it would have been neither necessary nor economical to use alkylate as a blending component in motor gasoline. However, today use of alkylate in premium motor gasolines is considered as an economical means to help meet the high octane demands.

To meet the increasing demand for alkylate, corresponding amounts of isobutane and olefins (propylene, butylene, amylene, and even ethylene) must be supplied. For the present and near future, at least, there appears to be no shortage of olefins, per se, although there may be a lack of facilities for recovering them in amount and purity required. However, the same cannot be said for isobutane, and there is a decided interest in the refining industry in processes for converting the more plentiful normal butane to isobutane for alkylation.

There are two general types of butane isomerization processes: vapor-phase and liquid-phase processes. Both process types were widely

used during World War II when the military demand for aviation gasoline, and hence for alkylate, became enormous. After the war, operation of some of these plants was discontinued. Of those operating today, five are Shell liquid-phase plants. It is the purpose of this paper to describe this process in its present state which involves a significant improvement of the original design used in four World War II plants and two postwar plants.

In the Shell process, liquid normal butane is contacted in a stirred vessel with a liquid catalyst consisting of a solution of aluminum chloride in antimony trichloride; anhydrous hydrochloric acid, which acts as a promoter, is added to the mixture. The resulting reaction produces isobutane with hardly any products boiling lower or higher than the butanes.

The process flow is illustrated in Figure 1. Normal liquid butane from storage is first charged through an alumina drier to reduce its water content to 0.001 weight percent or less. It then passes through a heater where the temperature is raised to about 180 F., through a catalyst scrubber column, and into the first of the reactor vessels. A small side stream of catalyst from the third reactor vessel is countercurrently contacted with the heated feed in the catalyst scrubber to recover aluminum chloride and antimony trichloride from it, leaving only an insoluble aluminum chloride-hydrocarbon complex sludge which forms as a consequence of feed impurities such as olefins or sulfur and the slight degree of side reactions. The sludge is rejected periodically from the bottom of the scrubber column.

The reactors are vessels equipped with mixing elements to provide intimate contacting of catalysts and hydrocarbon. The catalyst hydrocarbon phase ratio in the reactors is approximately one. A total hydrocarbon residence time of 10 to 15 minutes in the reactors is sufficient to achieve a high n-butane conversion to isobutane of 55 percent to 60 percent, depending on the isobutane content of the charge. The upper part of the contactors is separated from the main body by a baffle to provide a quiescent zone for phase separation of catalyst which may be entrained in the hydrocarbon.

Isomerizate from the last of the three contactor vessels flows through the catalyst removal column for separation of dissolved catalyst by simple fractionation. The catalyst recovered as bottom product is pumped back to the first reactor vessel. Part of the catalyst recycle stream is passed periodically through the $AlCl_3$ saturators to make up the $AlCl_3$ consumed and rejected as sludge. The isomerizate is taken overhead, condensed, and collected in an accumulator. Light ends, which may enter with the plant feed or which may result from side reactions, separate from the isomerizate in the accumulator and are vented through a small packed scrubber in which cooled stripper bottoms is used to wash the vent gas free of HCl. Liquid isomerizate from the accumulator is partly returned as reflux to the catalyst removal column; the remainder is charged to the HCl stripper where the acid gas is removed and recycled to the contactor. The isomerizate, thus essentially freed of HCl, is finally cooled and given a light caustic wash.

Using alkylate in premium motor gasoline blends now is considered economical. As more alkylation capacity is installed, greater attention will be given processes which convert the more plentiful normal butane to isobutane for alkylation feed.

The principal departure in design from that previously used and described by McAllister, et al[2] is in the reaction section. In the earlier designs only one reactor vessel was provided. The new design provides three reactor vessels connected in series. A study of the reaction kinetics indicated that in this process, staging of the reaction would significantly improve the approach to equilibrium, and hence the conversion per pass. This prediction has been verified commercially in a two-stage operation. With a normal butane feed containing 5 to 7 percent isobutane, it has been possible to produce isomerizates with up to nearly 62 percent isobutane when using two stages in series. With a single stage, and using the same feed, the isobutane content of the isomerizate varies between 50 and 52 percent. This increase in conversion obtained by staging is achieved with no change in the operating conditions, particularly with no change in residence time; that is, maintaining the total reactor volume in multi-stage operation the same as in single-stage operation. It is calculated that the addition of a third stage will effect a further significant increase in conversion. Beyond three stages the effect of staging on conversion progressively diminishes, and it is questionable that use of more than three reactor vessels is justifiable.

An important feature of the liquid-phase process is its operability with n-butane charge streams containing impurities such as olefins and sulfur compounds in concentrations prohibitive in the vapor-phase processes. Catalyst activity is maintianed constant through the continuous removal of degradation products resulting from reaction of impurities with the catalyst. This is achieved by means of the catalyst scrubber. The isomerizate composition is therefore constant. This simplifies controlability of

Normal pentane may be converted to isopentane in a liquid-phase butane isomerization plant. The only significant change would be the addition of a small compressor for circulating hydrogen.

the operations downstream of the reaction section including deisobutanization.

The recommended feed specifications are given in Table 1. However, it has been possible to operate plants charging feeds containing as high as 2.5 mole percent unsaturates. A higher impurity content will, of course, increase the rate of catalyst consumption. For the recommended maximum feed impurity content, the chemicals consumption is given in Table 2.

TABLE 1—Feed Specifications

	Recommended Maximum
Unsaturates	0.05 mole percent
Sulfur	0.005 percent w
Water	0.001 percent w
iC_{5+}	1.0 mole percent

TABLE 2—Chemicals Consumption

	Lb/Bbl Net Isobutane
$AlCl_3$	0.10
$SbCl_3$	0.04
HCl	0.04
NaOH	0.01

A typical over-all material balance for operation with a two-stage reactor is shown in Table 3. The concentration of isobutane in the product is practically unaffected by the isobutane content of the charge, within the limits normally encountered. The presence of isobutane in the charge will, of course, adversely affect the conversion of n-butane to isobutane and hence the net isobutane production per unit of plant charge. The utilities required by a typical unit are given in Table 4.

TABLE 3—Typical Material Balance

	FEED		PRODUCT	
	Lb.	%v	Lb.	%v
C_3	.....	.....	.05	0.06
iC_4	5.00	5.18	60.50	61.47
nC_4	94.65	94.50	37.79	36.99
iC_{5+}	.35	.32	1.61	1.48
Loss	.....	.....	0.05	.....
	100.00	100.00	100.00	100.00

For a given feed, the liquid-phase process achieves substantially higher conversion per pass than vapor-phase processes. Costs of deisobutanization of the isomerizate are therefore relatively lower, particularly if the deisobutanizer handles isomerizate exclusively, (often a single deisobutanizer handles a C_4 steam in the alkylation process as well as isomerization plant product).

TABLE 4—Utilities

	Per Bbl. Net Isobutane
Steam (100 psig)	180 lb.
Cooling Water (30 F. rise)	560 gal.
Power	1.3 kwh

Basically, with the addition of a small compressor for circulating hydrogen, a liquid-phase butane isomerization plant can be used to convert n-pentane to isopentane. Hydrogen acts as a suppressor of disproportionation reactions which otherwise would be significant when processing pentane. In the process flow, the compressor takes suction from the accumulator following the catalyst removal column and returns the hydrogen to the reactor system. Because equilibrium in the C_5 system favors isopentane to a greater extent, conversion per pass of n-pentane is 5 to 10 percent greater than it is for n-butane at about the same temperature. Tidewater Oil Company's operation of their liquid-phase plant for production of isopentane during World War II is fully described by Galstaun.[3]

Because of the corrosive nature of the catalyst, the reactors, vessels, pumps, and lines in catalyst service are nickel clad or lined. Hastelloy B is also suitable, and it is preferred in lines, valves, and pump construction. All other equipment is carbon steel. When properly built, liquid-phase isomerization plants operate at high stream factors. On-stream times exceeding 95 percent have been experienced over 12-month periods.

Including a contingency of 20 percent, the bare equipment of a 1000 barrels per day isobutane liquid-phase plant is estimated to be about $240,000. The cost of the installed unit, within battery limits, can vary in the range of $800,000 to somewhat over $1 million, depending on the standards of construction and local conditions.

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About the Author

J. A. SAMANIEGO is engineer in charge of process design and technical service on licensed processes at Shell Development, Emeryville, Calif. He worked for Shell Oil Company from 1935-1936 and since then has worked in refinery chemical analysis, plant operation, research in distillation, column design calculation methods, and in various unit processes, process design and technical report editing. Samaniego holds B.S. and M.S. degrees from the University of California, Berkeley, and is a member of AIChE, the petroleum division of ACS and is currently co-chairman, Bay Area Engineers Week Committee. He served as chairman of the San Francisco Engineering Council in 1955 and is a past editor of "San Francisco Engineer."

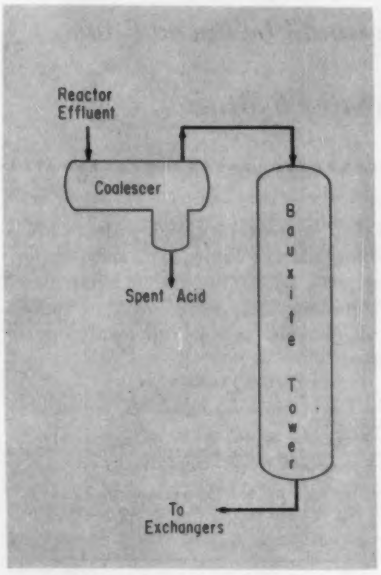

FIGURE 1—By placing the treater towers immediately following the reactor, protection is given the exchangers as well as the fractionating system.

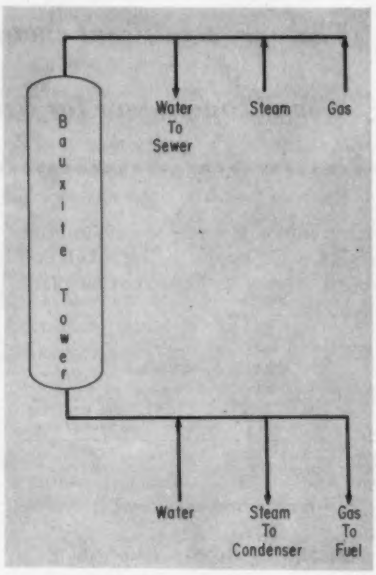

FIGURE 2—The regeneration cycle consists of water and steam desorption of the sulfur bearing materials, followed by natural gas drying of the bauxite.

How to Treat Alkylate

Having trouble with fouling? This company uses bauxite filter towers to treat the reactor effluent from their sulfuric acid alkylation plant.

V. L. Brant
D-X Sunray Oil Company, Tulsa

BAUXITE FILTERS are being used to replace caustic washing facilities at D-X Sunray's sulfuric acid alkylation plants. Their function is to remove acidic and sulfur bearing materials from the liquid alkylation reactor effluent. These materials cause corrosion and fouling in the fractionating system and loss in tetraethyl lead susceptibility in the alkylate product.

D-X Sunray's experience can be summarized as follows:

1. We have successfully used the bauxite treating system for two and one-half years.

2. We have reduced our maintenance and down time costs 85 percent for a savings of $175 per day.

3. We have reduced neutralizing and inhibiting costs $50 per day.

4. We have reduced the water content of the recycle isobutane, resulting in a savings of approximately $33 per day in acid catalyst.

5. By improving the lead susceptibility of the alkylate, up to $600 or $700 per day in tetraethyl lead savings is realized, when the alkylate is used in a motor blend.

D-X Sunray put its first sulfuric acid alkylation plant on stream in the fall of 1950. This plant contained a Kellogg cascade two-stage reactor with a design capacity of 800 barrels per day of total alkylate. The liquid reactor effluent was caustic washed after heat exchange with fresh feed and recycle and preceding the deisobutanizer tower. The fractionation system for the liquid effluent consisted of a deisobutanizer, debutanizer, and a rerun tower. We have revamped the plant in several stages and presently have a three-stage reactor and manufacture 3000 barrels per day of total alkylate. The fractionating system is the same with the exception of revamped internals in some of the towers and addition of heat exchange.

The problem of fouling was intensified with increased throughput. Immediately after start-up of the plant in 1950, it became apparent that we would have serious fouling and corrosion in the rerun tower. As we increased production to about 1800 bpd of total alkylate this condition became so severe that the rerun tower was down every six to ten days to clean the tube bundle in the reboiler and frequently to replace the risers, caps, and frogs in the tower proper. This condition became intolerable even with the best inhibitor system we could devise. We finally changed over to open steam in the fractionator and took the reboiler out of service. This resulted in the tower remaining on stream longer, but at a sacrifice of fractionation efficiency, resulting in loss of light alkylate yield.

From the beginning, we had some fouling upstream of the rerun tower, but it was of a much less severe nature. However, as we increased production to about 2200 bpd of total alkylate this also became intolerable. The deisobutanizer, which is the heart of any alkylation plant, was fouling severely. We were getting from two to four week runs before the purity of the overhead stream dropped to a point where it was necessary to shut down for cleaning this tower. We would chemically clean the tower and open and inspect. Frequently we had to remove the trays for mechanical cleaning.

Our laboratories had been actively

studying the problem throughout this period. Their initial work centered around secondary measures, such as inhibitors and emulsifiers to aid in control of the problem. These measures gave some relief but they became inadequate as throughput increased. The laboratories then became active in developing a means of removing the corrosive and fouling constituents from the liquid effluent. Obviously the caustic wash system was not removing all the corrosive constituents from the alkylate.

Investigation revealed that caustic washing was removing the acid and acid esters, however, some neutral sulfur bearing esters remained in the hydrocarbon. Some of these neutral esters were later decomposed in the fractionation system, leaving a carbonaceous deposit and causing an acid condition. Other more stable neutral esters survived the temperatures of the fractionating system and appeared in the alkylate product, causing less in tetraethyl lead susceptibility. Also, it was found that the fouling tendency of the alkylate was, in most cases, increased by caustic washing due to the solubility and entrainment of sodium compounds. After much investigation and many pilot plant tests, bauxite treating was found to be the answer.

The treating system consists essentially of a coalescer and two bauxite contacting beds. They are located in the liquid effluent system immediately following the reactor, and before heat exchange with the recycle and fresh feed. This location provides protection for the exchangers as well as the fractionating system. Figure 1 shows how the liquid effluent passes first through a glass wool coalescer which separates the finely suspended particles of acid from the hydrocarbon. This operation removes about 75 percent of the insoluble acid. Next, the liquid flows down through one of the bauxite treaters where the remaining soluble and insoluble acids and other sulfur bearing materials are removed. The hydrocarbon leaving the treaters is essentially free of all corrosive and fouling constituents.

The treaters are operated alternately, one on stream while the other is being regenerated. The on-stream life varies from 3000 to 6000 barrels of reactor effluent per ton of bauxite, depending upon the quantity of sulfur bearing materials to be removed. The regeneration cycle is shown in Figure 2. This step consists of water and steam desorption of the sulfur bearing materials, followed by natural gas drying of the bauxite. The bauxite is regenerated in place and can be used repeatedly. Bauxite is added to the filters only as necessary to replace losses during the regeneration cycle. The alkylate leaving the filter is not treated further, and the pre-existing caustic wash system remains only as a wide space in the line.

Figure 3 is a visual gage of the effectiveness of bauxite treating. The picture shows the deposits left in a 100 ml. distillation flask after boiling 100 cc. of weathered reactor effluent to dryness. Flasks 3 and 4 are typical of untreated reactor effluent. Flask 2 is typical of the residue that is left in the flask from caustic washed effluent. Flask 0 showing no deposit is typical of a bauxite treated reactor effluent. Flask 1 is the control point at which we switch filters. The effluent from the bauxite treaters will have an 0 flask rating from nearly the complete cycle. The transition from "0" to "1" flask rating takes place over less than 25 percent of the on-stream period.

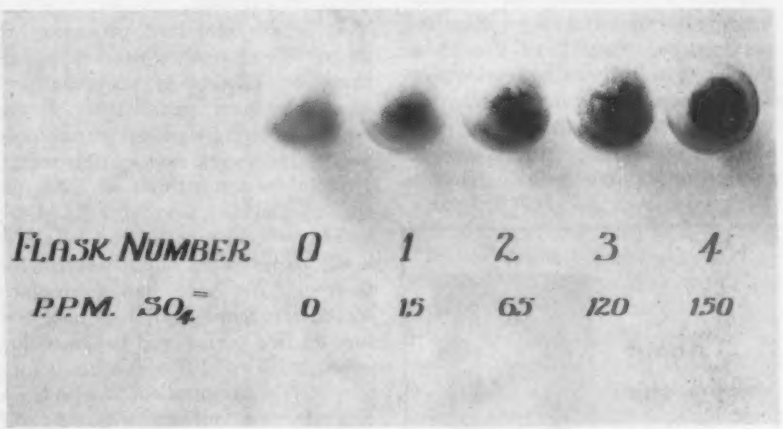

FIGURE 3—These deposits remained in the distillation flasks after 100 cc. of weathered reactor effluent was boiled to dryness

The mechanism of the filters is one of preferential adsorption. At the beginning of the cycle the bauxite adsorbs sulfuric acid, acid esters, and neutral esters. As the bed becomes loaded with these sulfur bearing materials, it will start desorbing the neutral esters. It is at this point that the flask will begin to show deposits. Since these are neutral esters, they do not show any acidity by normal titration methods. The beds have a large capacity for acid and acid esters. We have, as a matter of fact, purposely left a filter on stream for as long as 10,000 barrels per ton of bauxite without any show of acid in the treated product.

Below the flasks in Figure 3 you will note the approximate parts per million of sulfate represented by the deposits. I might caution here that ordinary sulfur determination methods are not sensitive enough for this test. We used an alcoholic potassium hydroxide digestion method, followed by quantitative sulfate determination. A typical charge sample would vary upward of 120 parts per million. A typical caustic washed sample will contain about 65 parts per million. The flask representative of the on-stream period shows no sulfate. Over the last 25 percent of the cycle, it gradually increased to 15 parts per million. These tests clearly show the relative corrosion and fouling tendencies of the various samples.

We put our bauxite treating system into service in the fall of 1954 and since that time have had very satisfactory service. We have definitely recognized four improvements.

1. Fouling and corrosion have been greatly reduced throughout the entire liquid effluent fractionating system.
2. The deisobutanizer overhead recycle stream is dry.
3. Operating costs for treating the effluent have decreased.

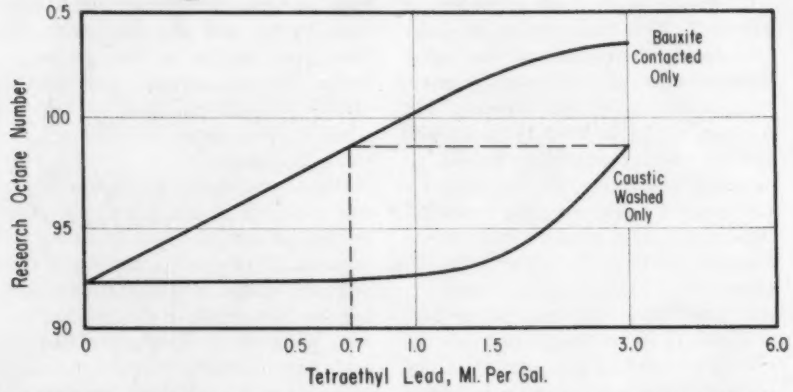

FIGURE 4—The use of bauxite treating gave a savings in tetraethyl lead equivalent to $600-$700 per day.

4. The tetraethyl lead susceptibility of the alkylate has greatly improved.

Reduction in fouling and corrosion has greatly reduced down time and maintenance costs. Even though we have had the filters in service since the fall of 1954 we have not had an opportunity to actually test the effectiveness of cleanup in the deisobutanizer tower. We have had over a six months' run without any decrease in the efficiency of the tower when the plant was shut down for reasons other than fouling.

It is our standard procedure to chemically clean the towers whenever the plant is down. As mentioned previously, before installation of the bauxite treaters we were getting only two to four week runs on this tower. Now at the rerun tower we have put the reboiler back into service and are getting several months' run before it needs to be taken out of service for cleaning. We have had to replace some risers, caps, and frogs only one time in this period and this was due mainly to a condition existing before the filters were installed. Over-all, we estimate that our maintenance and down time due to corrosion and fouling has been reduced 85 percent. This in round figures amounts to about $175 per day.

The water content of the isobutane recycle stream has been reduced 200 pounds per day, resulting in an acid catalyst savings. Before installation of the bauxite treaters the overhead reflux drum at the deisobutanizer tower also served as a water separator. This water was introduced into the system by the caustic and water wash operation. The recycle stream, saturated at the conditions of the reflux drum, contained approximately 300 parts per million of water.

We calculate from the equilibrium water content of bauxite that the recycle stream now has a water content of less than ten parts per million. The water content is so small that we are unable to get an accurate determination by conventional methods. The difference in water contents amounts to approximately 200 pounds per day. Considering that the useful range of acid catalyst is from 99 percent to 93 percent, this means a savings of 3300 pounds of acid per day, and at 1 cent per pound would mean $33 per day savings.

The total cost for treating the effluent has been reduced. In this case we were unable to separate the costs of the liquid effluent system from the costs of the refrigeration vapor effluent system. However, there has been no change in the refrigeration vapor effluent system, and any difference in costs was attributed to the bauxite treating. The total costs for caustic treating and corrosion inhibitors before installation of the bauxite filters was 2.6 cents per barrel of total alkylate. The comparable costs, using the bauxite treaters, is only 0.7 cents per barrel of total alkylate. This is a savings of 1.9 cents per barrel of total alkylate or a total savings of $50 per day in our system.

Figure 4 shows the comparison of F-1 octane rating of caustic washed and bauxite treated alkylate versus milliliters per gallon of tetraethyl lead addition. You will note that for the caustic washed alkylate no lead appreciation was obtained until after 1¼ milliliters per gallon of tetraethyl lead addition. The bauxite treated sample showed an immediate response. When the product is used as motor alkylate, this means a savings of $600 to $700 per day in tetraethyl lead.

The total savings to us amounts to $258 per day in operating and maintenance costs plus an additional $600 to $700 per day when the total alkylate is used in a motor blend. This may not be typical of all refineries, since the figures were based on our situation where we were operating at 300 percent of design capacity. This, we are sure, increased our fouling and corrosion problems above that which would be normally expected. However, we do feel that it would not be feasible to operate at our present throughput without the bauxite filters. This process is licensed by The M. W. Kellogg Company.

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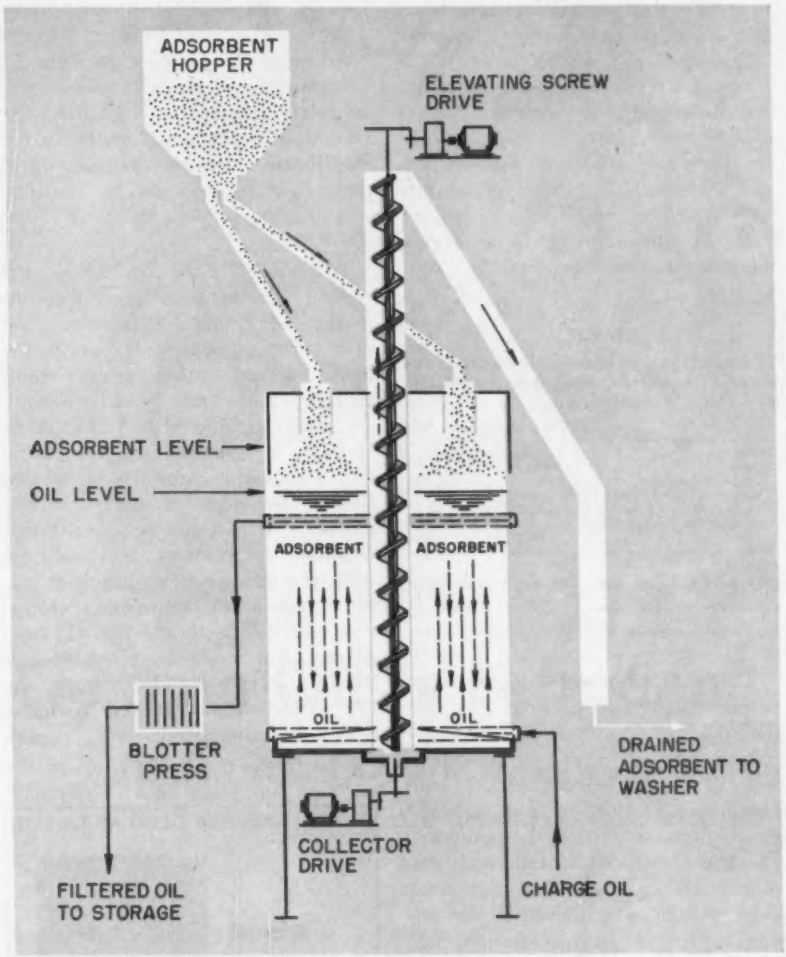
About the Author

VICTOR L. BRANT is director of chemical engineering for D-X Sunray Oil Company, Tulsa, where he directs chemical engineering development, pilot plant investigations, and technical service for petroleum refining. Brant graduated from the University of Missouri in 1949 with a B.S. degree in chemical engineering, then went to work for Gulf Oil Corp., as a production engineer where he remained for three years. He then joined the D-X Sunray organization where he has been in research, development, and technical service.



The continuous percolation method achieves a counter-current flow between oil and absorbent.

A New Way to Stability: Continuous Percolation

A counter-current flow between oil and adsorbent is achieved in this new process.

C. D. Laughlin
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Menlo Park, N. J.

THE CONTINUOUS PERCOLATION process is a new filtering method wherein both oil and adsorbent are in motion. The continuous method of percolating was designed and developed by Minerals & Chemicals because of the idle equipment time inherent with static-bed percolation and its equivalent high capital investment. Most of the housed equipment in a static-bed unit, under the best possible operating schedules, is in on-stream-and-producing service only about one-third of the time. The continuous percolation method achieves the purpose of eliminating down time and, correspondingly, decreasing equipment costs. The process and equipment are covered by U. S. Patent 2762510 (1956). Gwyn, H. M. & Laughlin, C. D..

Design Considerations. In static-bed percolation the oil or other liquid being treated flows either by gravity or mild pump pressure through a stationary bed of the granular adsorbent. If this passage of the oil through the adsorbent is visualized, it will be seen that incremental layers of progressively refined oil are successively being brought into contact with similarly thin layers of relatively fresher adsorbent. The filtration action so accomplished is equivalent to an infinite number of extreme fractionations and mixings. The selectivity of the forces of adsorption for the adsorbable constituents of the oil are thereby fully utilized in the most advantageous adsorption sequence and it is by this action that the superior quality as regards color stability, odor and oxidation stability are achieved.

In the continuous percolation apparatus these important relationships between oil movement and adsorbent are retained. Both oil and adsorbent are charged to and removed from the apparatus continuously, and no idle time or break in production is incurred as is the case in the static-bed operation. A true counter-current flow between oil and adsorbent is achieved, the treated oil leaving the filter vessel in contact with the freshest adsorbent and the spent adsorbent leaving in contact with and in adsorption equilibrium with the darkest oil. Each pound of adsorbent, therefore, carries from the system its maximum load of adsorbable impurities.

Percolator Construction. Continuous operation is achieved in a vertical, cylindrical percolator with smooth inside surfaces and an unencumbered interior. The adsorbent descends by gravity in a compact mass resembling a molded column shaped by the interior surfaces of the vessel. The oil

enters the lower end of the vessel and ascends counter to the descending adsorbent. Rates of flow of both oil and adsorbent are appropriately controlled to give the desired amount of refining when the oil has reached the upper levels.

At the proper level the oil is withdrawn through suitable draw-off lines. At the lower end of the vessel the descending column of adsorbent is, in effect, continuously sliced off in thin layers. The material so disengaged is then fed to a centrally located screw-type elevator and thereby removed from the percolation unit. Adhering oil drains from this separated adsorbent in that part of the elevating screw above the liquid level in the vessel.

A complete continuous percolation plant would comprise in addition to the filter itself, an adsorbent washer, an adsorbent dryer, and a reactivation kiln, as the essential items of equipment. The washer would receive the oily adsorbent from the filter and would advantageously be a continuously operating unit, probably of a design similar to the filter. A valuable volatile solvent would be employed as the washing solvent in most cases, and the continuous dryer would therefore incorporate a vapor recovery feature. The reactivation kiln would be the conventional multiple hearth type or the Thermofor, either of which are amenable to tying into a continuous system.

Pilot Scale Development. In several ways the adsorbent handling methods used in the continuous percolation process differ radically from conventionally accepted means for granular adsorbent transport and movement. To establish the soundness of these advanced ideas, and to obtain reliable design data which could be used in planning commercial-scale continuous percolation equipment, an adequately-sized pilot plant was designed and built. Mechanically, this pilot plant unit embodied all of the new and untried principles which would be involved in a commercial operation.

The pilot plant studies, extending over a period of approximately two years, explored the effects of important process variables. The commonly-used granular percolation adsorbents in various particle size grades were tested with oils representative of a range of viscosities and decolorization behavior. Operating variables such as adsorbent-oil ratios, oil rates, adsorbent rates and adsorbent bed proportion were studied. Further refinements were made in mechanical features such as the adsorbent disengaging mechanisum and the elevating screw.

TABLE 1

Typical Yield Comparison—Continuous Percolation Versus Static-Bed Percolation

	Continuous	Static-Bed
Charge Oil	Heavy Bright Stock	
Color	Dark	Dark
Operating Temp., °F	350	350
Viscosity @ 350° F SSU	45	45
Viscosity @ 350° F, cp	5.7	5.7
Oil Rate, Vol. Oil/Vol. Ads/Hr	0.6	0.5
Filtrate		
Color, A.S.T.M.	5	5
Yield, Bbls./Ton	13.7	11.6
Yield, Percent of Static-Bed	118	100

The significant results of this series of pilot plant tests showed: (a) that the yield of decolorized and finish refined oil per pound of adsorbent was 10 to 20 percent higher with continuous percolation than with the conventional static-bed operations; (b) that the mechanical methods employed for continuous bed movement were positive and delivered the adsorbent to the next operation, i.e., washing, in an oil-drained condition comparable with conventional gravity draining; and (c) that excessive adsorbent pulverization or other degradation effects were not present.

Economic Evaluation. With continuous percolation, the relatively high capital cost necessarily associated with static-bed construction, has been greatly reduced. Superior product quality inherent to the static-bed process has been retained and possibly further improved for the reason that true counter-current flow of oil and adsorbent is achieved in the continuous operation instead of being only partial as in the static-bed units.

For reasons previously given, true counter flow also reduces adsorbent turnover per unit of oil treated. Tests conducted with a laboratory pilot size unit have shown that up to 18 to 20 percent more oil can be finished in the continuous operation per unit of adsorbent handled. This is directly reflected in a still lower operating cost for percolation.

As another result of continuous operation, the product oil emerges continuously at predetermined color or other specification. This is contrasted with the batch system where the filtrate color, for example, varies from light to dark during the filter run, making product blending a constant chore.

It has been noted that the low operating cost of percolation filtration is derived from the fact that the granular adsorbent used can be reactivated and reused through many refining cycles. Only granular adsorbents may be handled in this manner. It has also been pointed out that if this reactivation must be performed outside the adsorber unit, the employment of a continuously operating adsorber (percolator) is mandatory from the standpoint of installed cost. In its essentials, continuous percolation provides a means for (1) employing low cost, reactivatable adsorbents, (2) in a continuous system, (3) at an installed cost in harmony with other alternates. ##

About the Author

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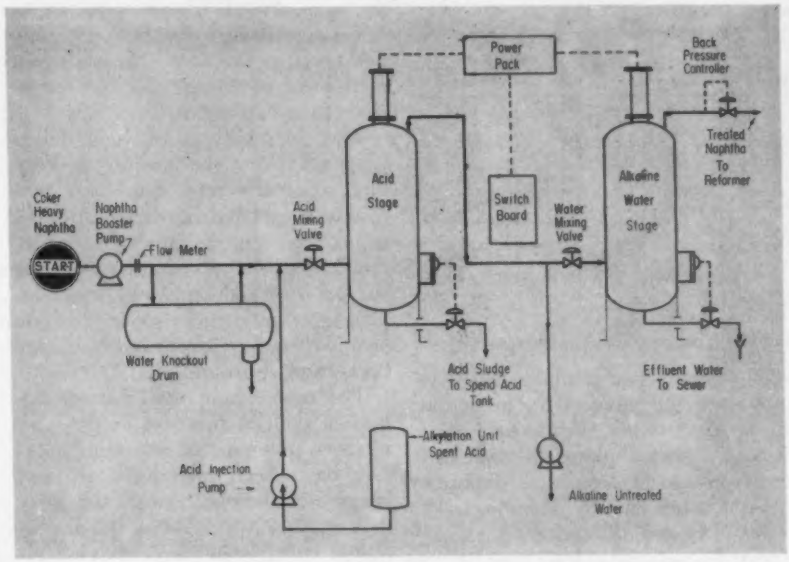

FIGURE 1—Spent alkylation acid and untreated subsurface water are used to treat the coker naphtha.

Treating Ousts Nitrogen

Ohio Oil is the first to use an electrofiner for nitrogen base removal. Here are the data on the treatment of a coker naptha.

R. W. Stark, The Ohio Oil Company, Robinson, Ill.
Fred D. Watson, Petreco Division of Petrolite Corporation, St. Louis, Mo.

THE FIRST commercial application of Petreco Electrofining for the removal of nitrogen base material from coker naphtha was put on stream at the The Ohio Oil Company refinery, Robinson, Ill., in July, 1956. For this application a two-stage acid-alkali treatment was used. This consisted of two 42-inch diameter by approximately 8-foot-high straight section treaters powered by a single 115-volt power pack. Treatment is with d.c. power converted from the refinery's 115-volt a.c. circuit.

Treatment is continuous, the charge being taken directly from the naphtha stripper at the coker, through a rate of flow control, and on to a booster charge pump. The booster pump charges through a water "knock-out" drum, then through the treaters, and finally to the reformer charge system. There is no intermediate storage, nor is it necessary to provide any additional treatment to the coker naphtha prior to its blending with the straight run charge to the reformer. The coker distillate stream is approximately 1000 barrels per day and represents 15 percent of the total reformer charge. The water "knock-out" drum installed in the line ahead of the first stage of treatment removes any free water from the distillate before acid is applied.

Coker naphtha is intimately contacted with alkylation acid, and this mixture of acid and naphtha is then subjected to the action of the electric field. The electric field coalesces the dispersed phase and separates the spent acid from the naphtha. During the treatment, the degree of dispersion and the time of contact are closely controlled by instrumentation.

A minimum of contact time with the acid, plus a rapid separation of the acid from the naphtha, made possible by the action of the electric field, results in the removal of nitrogen base material without materially affecting the olefin content of the coker naphtha. This treatment also limits the loss of product to the acid sludge to a very low value, as evidenced in the data given in Table 1. The acidic insoluble-phase in the naphtha overhead from the first stage of the Electrofiner is less than 10 ppm.

TABLE 1—Acid Inspection

	Spent Alky Acid	Acid Sludge
Concentration of acid	89.3	48.7
Arsenic content ppb	240	490
Calculated hydrocarbon loss to acid sludge less than 0.5 percent.		

Spent alkylation acid used in treating the coker naphtha is taken from the refinery alkylation unit at about 90 percent acid. The acid sludge from the treaters is pressured back into the spent alkylation acid tank, where it becomes blended with the acid withdrawal from the alkylation unit. Dilution of the spent alkylation acid, resulting from the acid sludge from treatment, lowers the acid content of the spent alkylation acid by about 1 percent. The mixture of sludge and spent alkylation acid, now 89 percent acid, is shipped out for regeneration in the usual manner without price penalty. Withdrawal of acid sludge from the treaters is controlled by a level controller, such control being possible because of the fluidity of the acid sludge produced.

The second stage of the Electrofiner treatment is the neutralization step. In this stage the naphtha receives an alkaline water wash to neutralize any residual acid carryover from the acid stage. Treating action is obtained by intimately mixing the

TABLE 2—Typical Operating Conditions

Coker naphtha charge, bbl./day	1200
Acid dosage, lbs./bbl.	0.5
Acid mix valve pressure drop, psi	10
Water in neutralization stage, Vol. %	4
Water mix valve pressure drop, psi	2
Acid stage insoluble phase carryover, percent	trace
Water stage insoluble phase carryover, percent	trace
Power consumption, KW	less than 1
Caustic added to water, lbs.	0

TABLE 3—Typical Sample Inspection

Sample Set	I		II	
Stock, Coker Naphtha	Raw	Treated	Raw	Treated
Gravity, °API	49.3	49.3	49.6	49.6
Distillation, °F.				
Initial Boiling Point	248	248	232	254
10 percent	294	292	290	292
50 percent	332	330	330	330
80 percent	364	364	362	362
90 percent	380	380	376	378
End Point	420	430	416	420
Sodium ion, ppm	0.0	0.5	0.0	0.5
Nitrogen, ppm	116.0	3.36	121	4.4
Olefins, percent	45.7	43.3	42.9	41.9
Aromatics, percent	13.3	12.4	13.8	13.7
Paraffins, percent	41.0	44.3	43.3	44.4
Acid Oils, ppm	298	135	....	....
Mercaptan, Weight percent	.034	.015	....	....
Lead, ppb	80	less than 10	....	....

About the Authors

Stark

Watson

ROBERT W. STARK has been with The Ohio Oil Company as process engineer since his graduation from Rose Polytechnic Institute where he received a B.S. degree in chemical engineering. For the past ten years he has worked as process engineer on crude distillation, fluid catalytic cracking, alkylation delayed coking, thermal cracking and linde copper treating units. He was process engineer and part project engineer for the petrolite unit on initial setup. Stark is a registered professional engineer in Illinois.

FREDERICK D. WATSON is process engineer at Petrolite Corporation, Petreco Division, Toledo, Ohio. From 1942-45 he served as Captain of Engineers in the U. S. Army Air Corps. Since joining Petrolite in 1945 he has been service engineer, service supervisor, and process engineer of the Eastern Division. Watson holds a B.S. degree in engineering from the University of Toledo, and is a registered engineer in Ohio.

alkaline water and naphtha and then subjecting the mixture to the action of the Electrofiner electric field. The dispersed water phase is coalesced and separated from the naphtha. About 4 percent by volume wash water is used and is continually withdrawn by automatic level control.

The effluent naphtha from this second stage contains less than 10 ppm water in an insoluble phase. The sodium ion content of the treated naphtha is less than 0.5 ppm. Other impurities are removed by this treatment, offering side benefits to the refiner. There is an 87 percent reduction in lead; a 50 percent reduction in mercaptan; a 90 percent reduction in dissolved oxygen; a 30 percent reduction in arsenic; and some reduction in acid oils.

While the acid dosage used is low, being one-half a pound per barrel of naphtha, it is quite adequate for effective nitrogen removal, resulting in 97 percent removal of total nitrogen, or 99 percent removal of the nitrogen base.

In the neutralization step it was originally planned to use caustic. In the actual operation of the plant, however, no caustic is required. The refinery untreated subsurface water used in the neutralization stage has enough alkalinity to neutralize the small amount of residual acidity from the first stage, and maintain an effluent wash water pH in the 6.5 to 6.8 range.

Since the acid used normally is spent alkylation acid, and since there is no penalty in the resale of diluted spent alkylation acid shipped for regeneration, the actual cost of the acid used in this treatment is negligible. Alkaline water used in the neutralization is untreated water which also has a very low dollar-value. The electric power consumed in the treatment is lower than that required to light the area. Power for pumping naphtha, acid, and water are the only additional power costs. No additional manpower is required for the operation of the Electrofiner.

The corrosivity of the acid sludge removed from the treater is very low, since the acid dilution is primarily with hydrocarbon. Special protection is given only to the inlet line into the neutralization stage at the point of alkaline water injection. The unit has been in service for one year with no replacements necessary because of corrosion.

The problems in the reformer operation such as pre-heat fouling and nitrogen poisoning of reforming catalyst have been effectively reduced because of the operation of the Electrofiner. Also, previous to this installation, coker naphtha containing nitrogen was charged to the reformer through a clay filter. The clay lost its ability to remove arsenic from the total reformer charge very rapidly. This was found to be the result of a deterioration of the clay caused by the nitrogen base compounds. The nitrogen base material adversely affected the octane yield on the reformer itself so drastically that the coker naphtha could not be used as part of the reformer charge.

The selection of this type of treatment as opposed to hydrotreating was based on economics. The level of severity to hydrotreat for nitrogen removal would have required additional high pressure hydrotreating at high severity levels far exceeding Electrofiner operational costs.

The Electrofiner is located in the alkylation unit area. From the refiner's standpoint, it was more desirable to divert coker naphtha to the alkylation unit than to locate the treating unit in either the delayed coking unit area of the catalytic reforming unit area. Three considerations in making this choice were:

- Alkylation unit operators are trained and experienced in the handling of acid.
- There are available in the alkylation unit area safety devices such as showers, eye washes, etc. for the protection of operating personnel.
- Treating acid and acid disposal facilities are available with minimum piping cost. ##

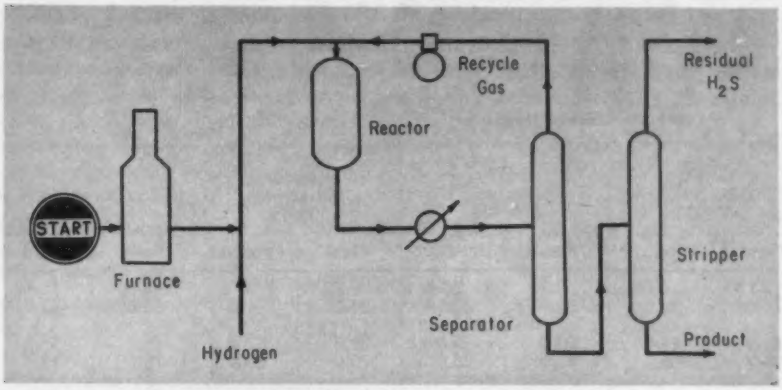

FIGURE 1—The economics of this process may be especially attractive when by-product hydrogen is available from reforming units.

Hydrogen Treating Helps Wide Range of Stocks

Hydrofining can be used to treat a variety of petroleum stocks. Here are data on stocks from naphthas to waxes.

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THE CONTINUED PUSH for better product quality is stimulating the use of catalytic processes for hydrogen treating. Hydrodesulfurization is one of the largest uses for these processes. However, hydrogen treating gives other improvements in product quality so that it is now considered for treating a wide range of petroleum stocks. This article describes the results of applying Hydrofining to many of these stocks.

How the Process Works. As shown in Figure 1, the feed enters a coil furnace where, depending on type of feed and purpose of treatment, it is heated generally to 550-800° F. The hot feed is mixed with fresh hydrogen-containing gas and is transferred to the top of a reactor. In the reactor, which contains a fixed bed of a regenerable catalyst, the feed is treated with hydrogen at pressures of 50-800 psi.

After leaving the reactor, the product is cooled and taken to a gas-liquid separator for product and gas separation. If necessary, the hydrogen rich gas may be recycled back to the reaction zone. After separation the liquid product enters a stripper where any residual hydrogen sulfide gas is removed.

What It Does for Some Stocks

Naphthas—For virgin naphthas, the process is most frequently employed to remove sulfur and other catalyst poisons from feed stocks to reforming units. In this application, Hydrofining serves to improve reforming catalyst activity and life and to reduce the tendency of the feed stocks to corrode reforming unit equipment. Hydrogen consumption is very low in this service, and the treat gas is often suitable for re-use in treating a heavier distillate stock. Typical results obtained for catalytic reformer virgin feed stocks are shown in Table 1.

In treating cracked naphthas, sulfur content is reduced, storage stability improved, formation of gummy deposits prevented, and the properties that lead to engine fouling is corrected. By careful selection of operating conditions, saturation of high-octane olefinic components is minimized. Leaded octane numbers remain essentially constant, as shown in Table 2.

Solvents—Odor and other quality specifications for solvents used in the dry cleaning and paint industries are very high. Treating under mild conditions improves odor. Even when the source of the naphtha is a sweet crude, it is often desirable to remove traces of odor. When the source is a sour crude, such as Kuwait, more severe conditions are needed to reduce sulfur as well as to remove other sources of objectionable odors.

Heating Oils—Where sulfur is not a problem, adequate sweetening and odor improvements can be attained by very mild treating conditions aimed at removing the mercaptans present with minimum hydrogen consumption. If sulfur content is a problem, more severe operations can be employed. Experience has shown that carbon residue is a problem when cracked stocks are blended with conversion-sweetened virgin heating oils.

TABLE 1—Virgin Naphtha

CRUDE SOURCE Boiling Range, °F.	WEST TEXAS 200/320		MIDDLE EAST 200/300	
	Feed	Product	Feed	Product
Sulfur, Weight Percent	0.12	0.001	0.10	0.001
Mercaptan Number	33.0	0.0	18.0	0.0
F-1 Octane				
Clear	63.5	64.0	48.0	50.0
+2cc TEL/gal	75.0	81.0	64.0	70.0
Yield, Volume Percent	....	100.0	....	100.0

Treating the cracked stock eliminates this problem. The benefits of treating these oils are shown in Table 3.

Diesel Fuels—With a trend toward a demand for lower sulfur-content diesel fuels, treating permits use of sour crudes to make quality fuels. It is possible also to upgrade cracked middle-distillate stocks to diesel fuel. The treating of cracked stocks removes sulfur and increases API gravity without any increase in viscosity

TABLE 2—Cracked Naphthas

Type of Naphtha	Light Catalytic		Heavy Catalytic		Heavy Thermal		Visbreaker	
Boiling Range, °F.	200/350		270/420		300/450		150/430	
	Feed	Product	Feed	Product	Feed	Product	Feed	Product
Sulfur, Weight Percent	0.18	0.02	0.20	0.14	0.28	0.12	1.00	0.10
Bromine Number	71.0	33.0	30.0	27.0	34.0	24.0	50.0	23.0
F-1 Octane								
Clear	88.9	85.9	90.0	90.0	59.5	53.4	71.2	63.6
+2cc TEL/Gal	94.2	93.2	95.0	95.0	70.0	69.8	76.4	75.7
F-2 Octane								
Clear	77.5	77.5	79.0	79.0	54.7	52.4	66.2	62.4
+2cc TEL/Gal	83.3*	83.3*	84.0	84.0	64.0	63.9	71.8	73.6
Breakdown, Min. (inhib.)	75.0	375.0	465.0	1,440+	70.0	1,440.0	120.0	1,090.0
G.M. Gum (inhib.)	15.0	2.0	3.0	0.5	12.0	0.5	33.0	5.0

* Uninhibited

TABLE 3—Heating Oils

Feed Source	West Texas (Virgin)		West Texas (Virgin)		Catalytic Cracking		Thermal Cracking	
Boiling Range, °F.	330/530		360/655		495/650		300/665	
	Feed	Product	Feed	Product	Feed	Product	Feed	Product
Sulfur, Weight Percent	0.67	0.47	0.92	0.77	1.4	1.3	1.6	1.2
Copper Number	91.0	<1.0	92.0	<1.0	5.0	<1.0	24.0	<1.0
Carbon Residue (10% Bottoms)	0.07	0.01	0.03	0.02	0.13	0.03	0.40	0.08
Carbon Residue Blending Value	....	....	....	....	0.37	0.03	0.49	0.08
Color, Tag Robinson	24.0	20.0*	17.0	21.0	16.0	18.0	8.0	13.0

* Saybolt Color

TABLE 4—Diesel Fuels

Crude Source	West Texas			Elk Basin		83% Virgin Arabian 17% Catalytic Stock	
Boiling Range, °F.	(310-640)			(480-635)		(495-680)	
	Feed	Product	Product	Feed	Product	Feed	Product
Sulfur, Weight Percent	0.92	0.50	0.15	1.3	0.25	1.6	0.35
Copper Number	92.0	<1.0	<1.0	34.0	<1.0	....	<1.0
Gravity, A.P.I.	37.9	38.4	38.4	31.4	33.5	30.0	32.0
Aniline Point, °F	143.0	145.0	150.0	154.0	154.0	151.0	154.0
Diesel Index	54.0	56.0	58.0	48.0	52.0	45.0	50.0
Cetane Number	53-55	53-55	53-55	46.0	46.0	51.0	52.0
Bromine Number	....	....	....	....	....	10.0	1.0
Color, Tag Robinson	17.0	18.0	17.0	14.0	22.0	....	....
Carbon Residue, (10% Bottoms)	0.03	0.01	0.01	0.02	0.02	0.06	0.02

About the Authors

L. E. CARLSMITH is a member of Esso Research and Engineering Company's Process Licensing staff. He has three degrees: a Ph.D. in industrial engineering from Columbia University; a B.S. degree in chemical engineering from Stanford University, and an M.S. degree in the same field from M.I.T. His company service totals 22 years.

Carlsmith

Haig

R. R. HAIG, a member of Esso Research and Engineering Company's Process Licensing staff, received his B.S. degree in chemical engineering from the University of Rochester. He started with Esso Research in 1946 after serving for a short period with another oil company. During World War II he saw active duty with the Navy.

or pour point. Product improvements realized by Hydrofining diesel fuels are shown in Table 4.

Kerosine—Treating may be desired for kerosines from either sweet or sour crudes. It is especially attractive in refineries where sweet crude is not normally available. Hydrofining effects improvements in sulfur content, odor, color, and burning qualities (as measured by wick char). The results of treating kerosine are shown in Table 5.

Catalytic Cracking Feed—Treating can significantly increase the value of either cracked or high-sulfur gas oils for feed to catalytic cracking. For example, product distribution from cracking may be greatly improved, sweetening requirements of cracked products are reduced or eliminated, and the need for scrubbing the catalytic gas stream is avoided. Treating also makes possible cheaper materials of construction for new catalytic cracking units and reduces equipment corrosion in existing ones.

Typical results for treating catalytic cracking feed stocks are shown in Table 6.

Lubricating Oils—Hydrogen treating of lubricants has many advantages over previous lube oil treating techniques. The equipment is relatively simple and operation is continuous. Control of lube quality from varying crude sources is enhanced and there are no major waste disposal problems. Color, odor, acid value, de-emulsibility, carbon residue, sulfur content, and response to additives are all improved.

In the case of motor oils, viscosity index is slightly improved, with no increase in cloud or pour point. Also sludge dispersing characteristics are improved and Conradson carbon residue is reduced. Data on Hydrofining of lubricants are shown in Table 7.

Waxes—Because wax is widely used in food containers and packaging, it is important that it have a high degree of purity as measured by the USP (United States Pharmacopoeia) acid test. From the standpoint of customer acceptance, it is also desirable to have good odor and color stability. All of these properties may be improved by hydrogen treating without changing the melting point of the product.

TABLE 5—Kerosine

CRUDE SOURCE Boiling Range, °F	MIXED SWEET (340-545)		WEST TEXAS (310-515)	
	Feed	Product	Feed	Product
Gravity, °A.P.I.	41.7	42.0	40.6	41.5
Sulfur, Weight Percent	0.10	0.04	0.55	0.02
Copper Number	....	<1	68	<1
Doctor Test	....	Pass	Fail	Pass
Odor	Fair	Good	Poor	Good
Color, Saybolt	+20	+28	+3	+24
Color hold, Saybolt	+18	+26	....	+21
Wick char	30	18	65	20
Smoke Point	22	22	20	20

TABLE 6—Catalytic Cracking Feed

FEED	WEST TEXAS GAS OIL		
	Raw	Hydrofined	
Inpsections			
Gravity, °A.P.I.	22.3	26.2	
Sulfur, Weight Percent	2.11	0.22	
Conradson Carbon	0.9	0.3	
Nitrogen, Weight Percent	0.20	0.15	
Nickel, ppm	0.52	0.25	
Vanadium, ppm	1.47	0.42	
Catalytic Cracking Yields			
Carbon, Weight Percent	3.2	2.5	3.2
Conversion, Volume Percent	48.0	48.0	55.0
Dry Gas, Weight Percent	6.1	5.3	6.5
C_4's, Volume Percent	9.7	10.3	15.1
Naphtha, Volume Percent	38.5	39.4	41.1
Heating Oil, Volume Percent	24.7	26.3	24.5
Cycle Stock, Volume Percent	27.3	25.7	20.5
Catalytic Naphtha Quality			
Sulfur, Weight Percent	0.27	0.04	0.04
F-1 Octane			
Clear	93.0	93.6	94.3
+3cc TEL/Gal	97.0	98.4	98.9
F-2 Octane			
Clear	79.5	80.1	80.6
+3cc TEL/Gal	82.6	85.5	86.1
Accelerated Storage Stability, Weeks	1.0	5+	5+

TABLE 7—Lubricants

Crude Source...	Leduc		Leduc		Panhandle		Coastal		Colombian		Tia Juana	
	Feed	Product	Feed	Product	Feed	Product	Feed	Product	Feed	Product	Feed	Product
Viscosity, SSU/ 100° F.	607.0	587.0	1,708.0	1,670.0	326.0	302.0	1,067.0	1,018.0	1,512.0	1,068.0	2,190.0	1,470.0
Viscosity Index	87.0	87.0	89.0	89.0	101.0	102.0	65.0	66.0	12.0	27.0	32.0	45.0
Color, Tag Robinson	7.0	21.0	1.0	11.0	4.0	16.0	3.0	12.0	2.0	11.0	1.0	9.0
Colorhold, Tag Robinson	4.0	20.0	.....	10.0	4.0	15.0	.....	11.0	1.0	9.0	.....	6.0
Sulfur, Wt. %	0.19	0.04	0.20	0.07	0.35	0.10	0.15	0.12	0.93	0.43	1.80	0.82
Gravity, °API	28.1	28.3	26.8	26.9	29.9	30.8	24.9	25.2	20.0	21.6	19.3	21.8
Flash (COC) °F	480.0	495.0	570.0	580.0	465.0	450.0	485.0	485.0	470.0	445.0	500.0	460.0
Pour Point, °F	20	25	25	30	10	35	15	20	0	15	5	10
Conradson Carbon, Weight Percent	0.04	0.02	0.27	0.16	0.03	0.02	0.08	0.07	0.22	0.08	0.88	0.33
Neutralization No.	260.0*	22.0*	1,200.0*	20.0*	.....	.....	0.12	Nil	2.30	0.01	0.94	Nil

* Steam Emulsion No.

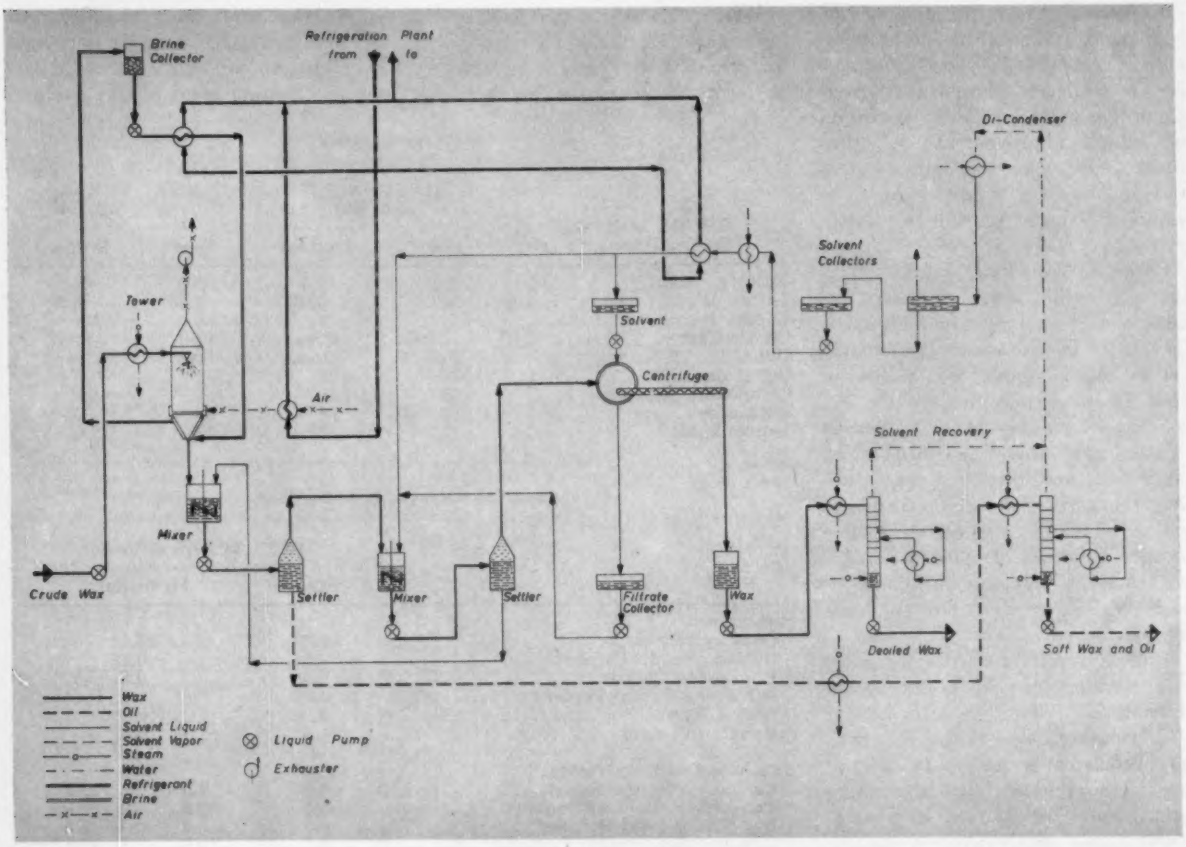

FIGURE 1—After the wax particles are formed by spraying the charge into a stream of air, dichloroethane is used as a solvent for the oil.

Try This New Way to Get Oil-Free Wax

Here is a description of a new spray de-oiling process. The cost of a plant would be about $40 per annual ton of charge.

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Frankfurt Am Main, Germany

A NEW PROCESS called The Spray De-Oiling process has been developed by The Edeleanu Company. It produces an oil-free wax by forming small wax particles within a stream of air and then dissolving the resulting oil film from the particles.

Preliminary work was carried out at the Paraffin and Petroleum Works in Messel. These studies have been duplicated and proven in a large commercial plant for the past two years. This plant is in operation at the Hamburg Mineral Oil Works, Hamburg

Translated by Edwin J. Barth, petroleum consultant, New York.

(Ernst Jung). Its throughput is about 55 tons per day.

The continuous process is very uncomplicated, the equipment is simple and easily accessible, and every phase of the operations is thoroughly controllable. The plant is equipped with automatic regulators and controls, and can be manned with one shift-foreman and two helpers.

The flow diagram is shown in Figure 1. Crude paraffin is charged at a pressure of about 75 pounds per square inch to a spray tower at a temperature of 140 to 175 degrees Fahrenheit. The liquid enters the tower at the top and is atomized by a spray nozzle arrangement situated within the tower. Minute paraffin droplets fall down through the tower against an ascending stream of air, solidifying into solid granular particles of very small but uniform diameter. The flow of these particles is continuously maintained through a brine-cooled funnel arrangement (conical section) at the bottom of the tower into the mixer below.

Cooled or ordinary air flows continuously upward through the spray tower and its temperature is varied depending on outside climatic conditions and on the throughput. The tower here acts as a stack in creating efficient up-flow of air.

The current of air cools the particles of wax to within a few degrees above air inlet temperatures. The particles fall into the mixer below as dry powder even though very thin oil films cover each minute particle.

The purpose of the mixer vessel below is to extract this oil film and the small quantity of very low melting point wax by means of a suitable solvent. The latter is used in a later stage and is recycled since it usually is not completely saturated with oils and still shows high solvency for further extractions.

It is important to stress that the low melting point paraffins can be selectively extracted or dissolved to a definite degree or point. Stirring the mass in the mixer at slow and uniform rates of agitation aids in this selective solution effect. Mixer temperatures are regulated to obtain any desirable solvent temperatures needed for operating.

The mixture of solvent and waxes is next pumped from the mixer into the settler, which is fitted with a cone shaped top. Lighter specific gravity wax separates from the heavier oil containing solvent and thus accumulates in the cone above. Solvent containing extracted oil drawn from the bottom of the vessel is recovered by distillation in a recovery system which is part of the plant. The low-melting waxes and oils recovered here from the solvent are sent either to the cracking plant or are used as fuel.

TABLE 1—Processing Raw Crude Paraffin Wax

CRUDE WAX SOURCE	Light Spindle Oil		Light Lube Oil	
Specific Gravity, @158 F.	0.780		0.787	
Melting Point, F. (ASTM D-87-42)	116.6		125.6	
Oil Content, Weight Percent (ASTM D-721-55T)	5.0		8.0	
Total Solvent, Volume Percent	300	500	400	600
Mixer, Temperature F.	54	54	60	60
De-Oiled Wax, Weight Percent	73	70	75	71
Oil Contents, Weight, Percent (ASTM D-721-55T)	0.4	0.2	0.4	0.2
Throughput, Pounds Per Hour	4,840	4,840	4,840	4,840
Steam, Pounds Per Ton	2,200	3,080	2,640	3,520
Power, Kilowatts Per Ton	86	102	94	100
Cooling Water, Gallons Per Ton	9,800	13,500	11,900	14,800

Note: The loss of solvent is the order of approximately 9—13 pounds per ton wax processed.

The light gravity wax accumulating in the cone top of the separator contains entrained solvent and some oils. It flows to a second mixer to be treated again with fresh portions of solvent at a similar temperature as before. The stream enters a second settler, separating again as before with a lighter gravity wax layer in the cone of the settler and solvent containing oils in solution below.

Very little oil remains to be taken up by the solvent during the second mixing, and the solvent leaving the second separator is practically clean and fresh. It therefore is used directly in the first mixer operation where it dissolves out appreciable quantities of oil.

The paraffin wax separated in the cone at the top of the second settler is next freed from last traces of oils in a centrifuge. Here the wax is given a thorough final wash with chilled fresh solvent. The filtrates or washings contain only very small amounts of oil, so that these liquids are pumped over to the second mixer for use there.

Wax separated from the centrifuge contains about 40 percent of solvent. This solvent is removed to completion in a distillation recovery system, obtaining finished wax and clean solvent.

The solvent is dichloroethane. It is used in the range of temperatures discussed above. In those ranges it shows good solvency for the oils without taking up appreciable amounts of waxes. Its favorable boiling point of 183.2 F. insures low vapor pressures in the various operations to be conducted. Condensation takes place at about 0.3 atmospheres.

Plants are built to operate, depending on the quality of wax to be made, with throughputs of from 30 to 55 tons per day of crude wax charge containing from 5 to 10 percent or more of oil to be removed.

Finished wax of oil content of 0.5 percent and lower (A.S.T.M., D 721-55 T) is easily obtained employing 300 to 400 volume percent of solvent for the mixing and the final washes. Wax as low as 0.2 percent oil content is obtained using 500-600 volume percent solvent. Other changes beside solvent ratio alterations can be employed to obtain low oil content—such as changing the spraying conditions, altering treating temperatures, etc. The quantity of dichloroethane in the finished wax has been determined to be well under 0.002 percent.

Table 1 shows the results of de-oiling two crude waxes of different origin by the new process.

The process will handle most crude waxes derived from very heavy lube distillates and crude cylinder stocks—materials which cannot be processed by usual wax-plant sweating procedures.

The advantages of the new process lie in the fact that it is not necessary to cool the material to be de-oiled to very low temperatures. Nor does the mass at any time need to be slowly warmed after crystallization—as is the case with the sweating process. Both these features of sweating are very time-consuming.

Heat set free in cooling the raw liquid wax and the heat of later crystallization are both absorbed and removed by the current of air in the tower; the latter is normally not precooled or only slightly so, in cases of

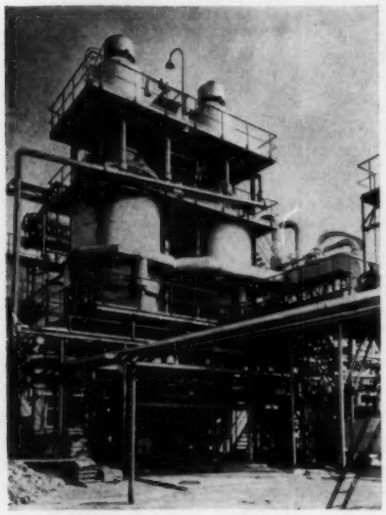

FIGURE 2—The mixers are below the spray towers in the Hamburg plant.

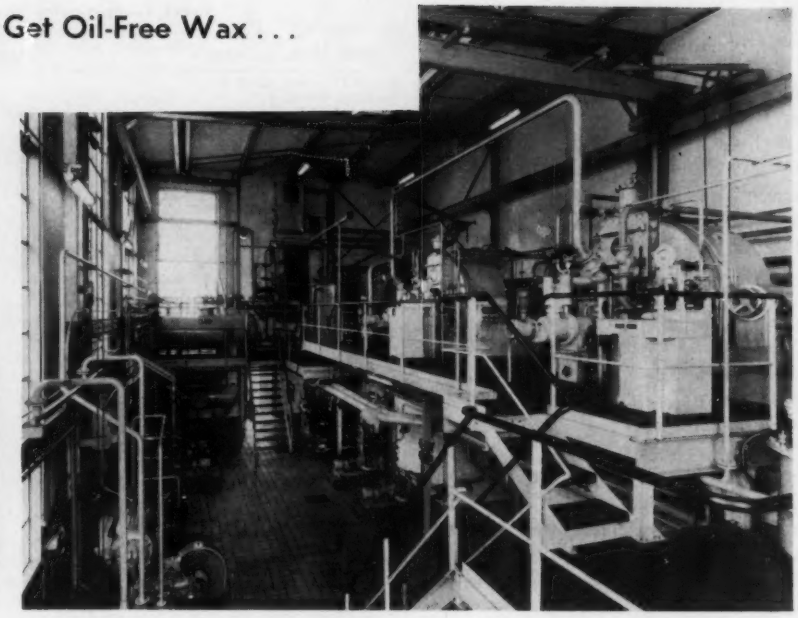

FIGURE 3—This view of the equipment building shows a mixer and a settler to the left of the automatic disc centrifuges.

hot days or operating in hot climates.

The function of the solvent confines itself to a leaching effect of the solid granular wax. The quantity of solvent used is therefore much less than if the total wax mass had to be completely dissolved in it, and later again removed. Solvent is recovered in the recovery system which uses exhaust steam in the heating units.

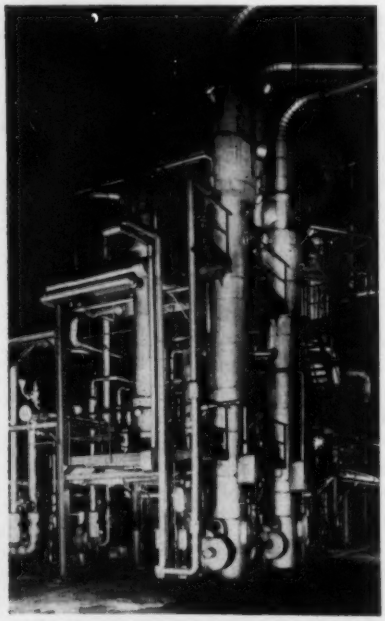

FIGURE 4—In these distillation towers the solvent is recovered from the wax and oil products.

These and other factors make recovery costs very low.

The solvent cooler is held between 40 F. and 60 F. temperature, depending on the type of wax to be processed. The air cooler for the spray tower and an exchange cooler for the cooling fluid surrounding the funnel are chilled by brine liquid cooled by ammonia evaporation.

In comparison to present day processing methods the new procedure consumes a minimum amount of energy or heat either for the cooling cycle or for heating. In other words, costly low temperature equipment, scraper-blade towers, etc., are not required. The necessary equipment operates at ordinary pressures, and corrosion problems are prevented by the choice of proper materials used in the fabrication of the vessels, towers, pumps and other equipment in conjunction with attendant good operating techniques. Simplicity of construction is uppermost. The spray tower consists of a hollow vertical chamber, at the top of which is fitted a trap to catch entrained wax particles in the exit air. At the bottom of the tower a trap or cone arrangement, encases a funnel, which is cooled by circulating brine or cooling water through it.

The mixers are ordinary vats or tanks fitted with the proper type of blade stirrers. The settling tanks are again of ordinary construction, are cylindrical vessels, cone-shaped at the top portion and are set between the two mixers. The final or centrifuge cycle consists of a bowl or shell-type centrifuge, and operates automatically.

The recovery of the solvent from wax and filtrate is carried out under a slight vacuum employing evaporating columns. They are heated by steam coils supplied with low-pressure steam. The vapors from the evaporators or still, if such is used, pass into the water-cooled condensers. The resulting investment costs are therefore quite low. Space requirements, based on a per day throughput, are consistently low. Labor requirements are such that a few operators can run the plant.

Costs for a complete plant ready for operation are approximately 150 to 180 German marks ($35-$42) per annual ton of charge. Such a plant will produce a finished wax of from 0.3 to 0.5 percent oil content, using 300 to 400 volume percent solvent. For the production of waxes of 0.2 percent oil content or less, the cost is increased by 15 percent approximately, due to the use of 500-600 volume percent of solvent.

The process may be licensed from the Edeleanu Company, Frankfurt on Main, Germany. The process is based on the following German patents:

DBP Nos. 928,726; 933,828; 934,660; 935,858; and 936,645. # #

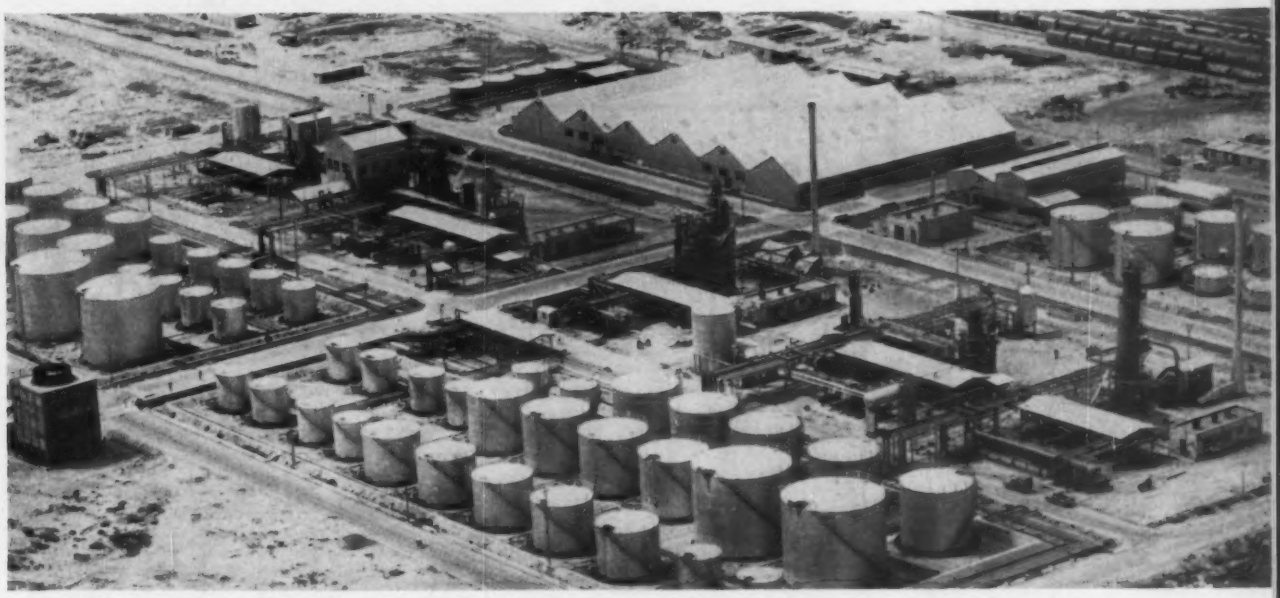

FIGURE 1—The new lube plant for the Iraq government. Left to right are: (1) clay percolation and acid treating, (2) propane dewaxing, (3) furfural treating, (4) propane deasphalting and asphalt blowing, and (5) vacuum distillation.

Baghdad's New Lube Plant Uses Furfural Refining

One of the features of this lubricating oil plant is the use of a rotating disc contactor in the furfural refining unit.

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Foster Wheeler Corporation
New York

RECENTLY COMPLETED for the Iraq government at Daura Baghdad is a complete lubricating oil processing plant comprising vacuum distillation, propane deasphalting, propane dewaxing, furfural solvent extraction and clay percolation. The complete plant, shown in Figure 1, was designed and constructed by Foster Wheeler.

One of the more important features of this plant is the rotating disc contactor in the furfural refining unit. This novel method of counter current extraction, advanced by the Shell Development Company replaces the conventional counter-current extraction tower.

The rotating disc contactor (RDC) offers a very flexible and efficient method for counter-current liquid-liquid extraction operations. This simple unit provides maximum countercurrent efficiency which can be maintained over a very wide range of throughputs and solvent ratios. The rotating disc contactor is very much shorter than a conventional packed or perforated plate tower of the same capacity.

The flow diagram for the process is shown in Figure 2. The feed entering the unit via a heat exchanger (this and other exchangers not shown) where it is preheated by hot furfural. The preheated charge then enters the rotating disc contactor where the combination of thorough mixing by the rotating discs and a liquid-liquid extraction between the charge and the furfural effects a separation into a refined oil (raffinate) and undesirable lube components (extract). The refined oil phase flows out the top of the rotating disc contactor and is preheated by heat exchange with the hot refined oil product being pumped from the steam stripper, and then enters the direct-fired heater. In this heater the mixture of furfural and refined oil, is raised in temperature and enters the refined oil stripper where, under vacuum, all traces of furfural are removed. The refined oil is pumped from the stripper through an exchanger and finally through a cooler to storage.

The furfural phase separating in the rotating disc contactor, contains the undesirable components of the charging stock. It flows from the bottom of the contactor, is preheated

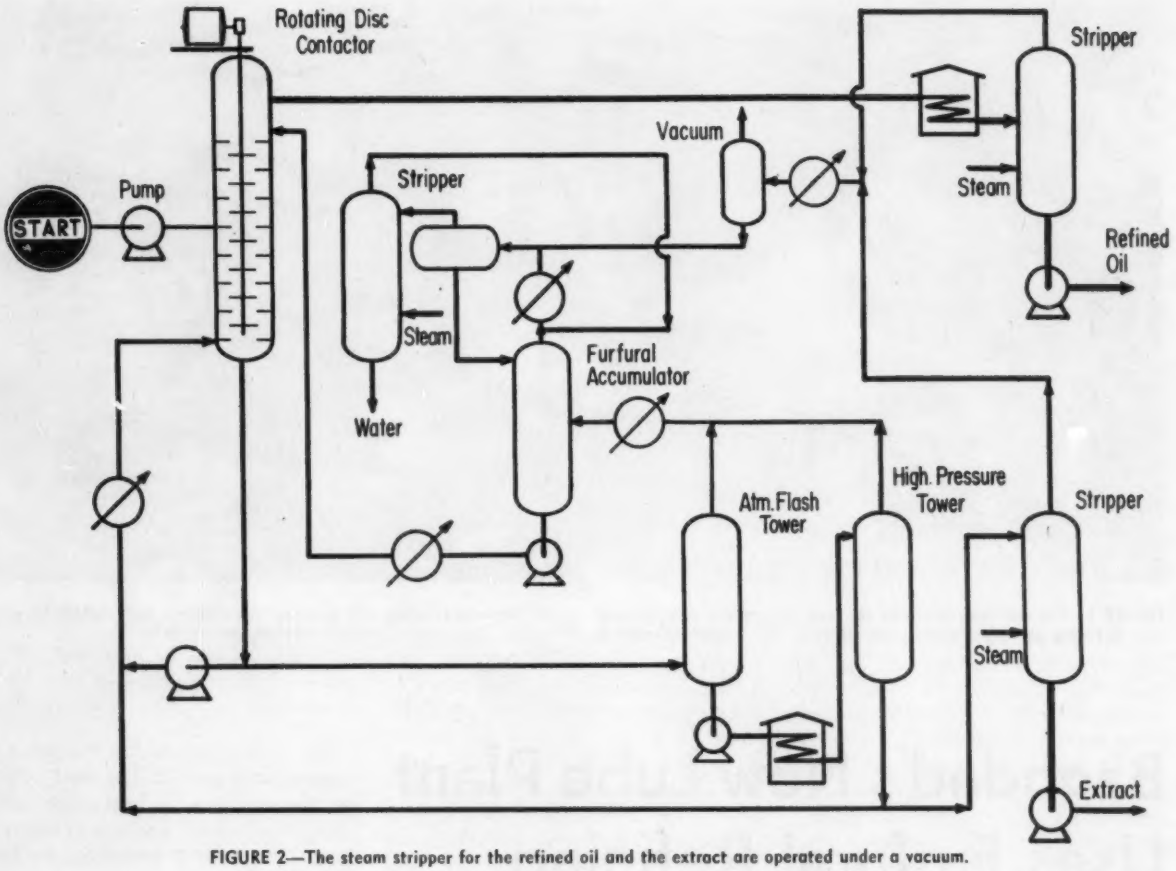

FIGURE 2—The steam stripper for the refined oil and the extract are operated under a vacuum.

by heat exchange at three different points in the system and finally enters the atmospheric flash tower. In this flash tower part of the furfural is vaporized, condensed in a vapor-heat exchanger and flows to the furfural accumulator. The bottoms from the atmospheric tower is pumped through a direct-fired heater and enters the high-pressure flash tower which removes practically all the furfural in the mixture. This furfural vapor is also condensed in a vapor-heat exchanger and enters the furfural accumulator.

The extract, containing traces of furfural, flows from the bottom of the high-pressure flash tower and enters a steam stripper where all traces of furfural are removed. The stripped extract is then pumped from the bottom of the steam stripper through a cooler to storage. A portion of the bottoms from the high-pressure flash tower is recycled to the lower section of the contactor to provide optimum concentrations in the extract phase to insure a maximum yield of refined oil.

From the steam strippers, which operate under a vacuum, the steam-furfural vapor passes through a condenser where all the furfural and steam is condensed. This mixture flows into a settling drum where a separation into two layers takes place, furfural containing a small quantity of water, as the bottom layer, and water, containing a small amount of furfural, as the top layer. This top layer is pumped into the steam stripper, the furfural is removed from the top as vapor and the water from the bottom of the stripper passes to sewer. The bottom layer enters the top of the furfural accumulator where the remaining water is flashed off and the furfural is recovered for further treating. This is essentially a recycle operation in which all the furfural is finally recovered. ##

About the Author

FREDERICK T. MERTENS is assistant manager of process design for Foster Wheeler in New York. He received his B.S. degree in chemical engineering from Cooper Union Institute of Technology in 1929, then went to work for Tidewater Oil Company at its Bayonne, N. J. refinery. In 1937 he joined Foster Wheeler in process design of the Refinery Engineering section.

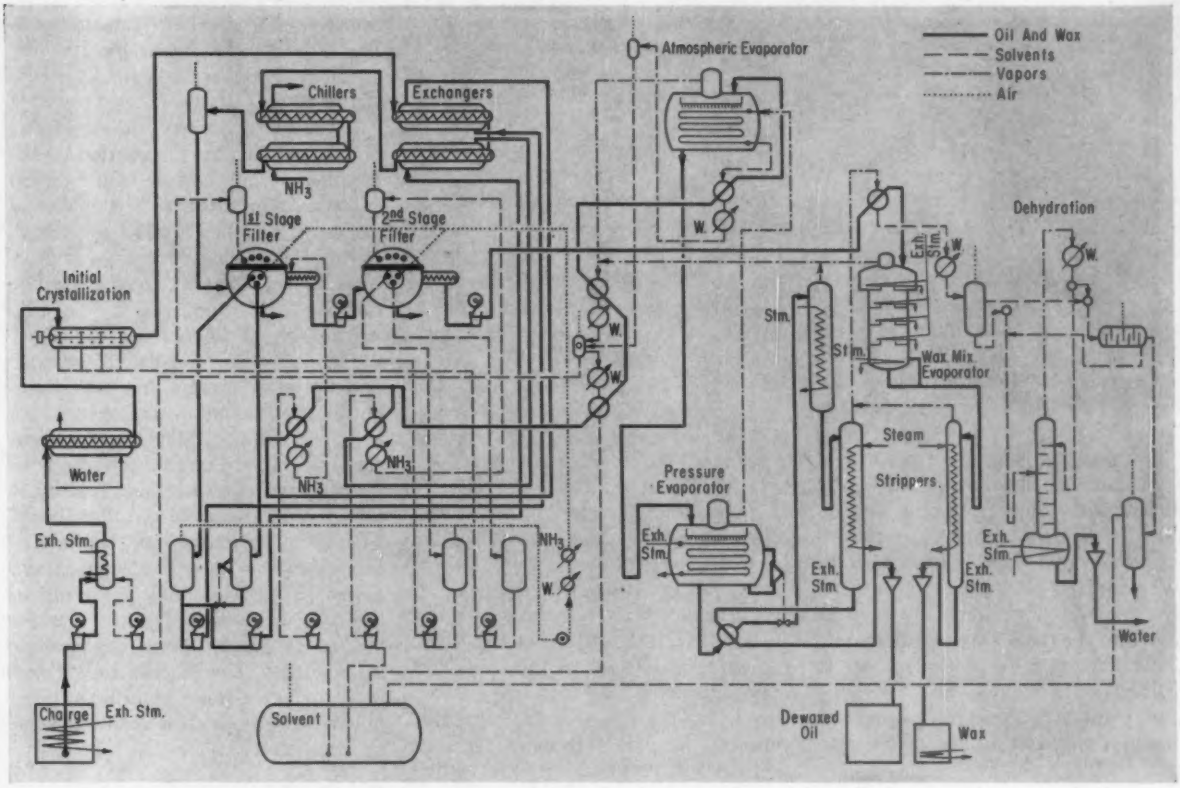

FIGURE 1—Very little instrumentation is used. Belt-driven piston pumps with adjustable stroke are used for circulation control.

They Use Benzene-Acetone to Dewax

Some of the older dewaxing solvents may be better in special cases. Here is a description of a dewaxing plant in Greece which uses benzene-acetone.

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THE SOLVENTS used for the dewaxing lubricating oil stocks now usually are methylethylketone mixed with toluene and benzene, propane, chlorinated hydrocarbons, etc. In some cases, however, one of the first dewaxing solvents of benzene-acetone is preferable. This article describes a small dewaxing plant operating in Greece where the benzene-acetone process is used. The Technical department of the Elbyn refinery planned and constructed this dewaxing plant in their refinery at Moshaton near Athens for the following reasons:

- It is easier to obtain supplies of benzene and acetone in the country.
- Because the climate is mild, lube oils with a pour point of 10 F. are considered satisfactory for most uses and only in special cases the lube oils must have a pour point of 0 F.
- The larger part of benzene and acetone, because of their low boiling point, can be recovered with low pressure exhaust steam and the remaining part is recovered by heating with steam of 220 psig without pipe heater or vacuum.

The process is in two stages. The wax from the first filtration is mixed with fresh solvent and passed to a second filter. The filtrated solvent of the second filtration is used for the initial solution of the charge oil.

The charge oil is heated and mixed with about 50 percent by volume of hot solvent, pumped from a small surge tank before the final cooling of the distilled solvent. The mixture is heated to 120-130 F. so that a clear solution is obtained. Then the mixture is cooled with water in a heat exchanger fitted with stirring paddles. In a following horizontal agitator, fitted with specially designed stirrers, in order to obtain a continually increasing stirring, is stepwise injected the main proportion of

solvent at 35 F. till the final solution is obtained. The proportions of this final dilution is 1:3 to 1:4 (depending upon the charge stock) and the final temperature is 60-70 F.

The first crystals are formed during this cooling and mixing. The rate of cooling is very important because it influences the final crystallization of the wax in the following chillers. The mixture in finally cooled in heat exchangers and by direct expansion of ammonia in chillers fitted with rotating scrapers. There the final low temperature is reached which influences the pour point desired of the oil.

The mixture is filtered in a rotating vacuum filter and the slack wax is washed with solvent precooled at the filtration temperature. The filtrate passes through heat exchangers in order to precool the oil-solvent mixture and the solvent, and to be preheated to the distillation temperature. The main quantity of the solvent is distilled in a double effect evaporator plant. The remaining solvent is recovered in a distilling tower and stripper.

The slack wax, while leaving the first filter drum, is mixed with fresh cooled solvent. This mixture is carefully repulped and then pumped to a second filter where the wax is thoroughly washed. The solvent from the second filter is used again to dilute the charge oil and to wash the slack wax in the first filter. Both filters are washed from time to time with hot solvent—the time depending upon the quality of the oils.

The equipment for the plant is represented by the flow diagram in Figure 1. Belt driven piston pumps with adjustable stroke are used to circulate the oil, the solvents, and the solutions and mixtures. Many years of experience have proved that this type of pump gives satisfactory service.

Two pumps are used to carry the solvent from the storage tank, thus forming two separate approximately equal solvent streams. One of these streams is used for repulping the slack wax, while the other is used for the final washing of the wax. The main filtrate of the first stage, after precooling the oil-solvent mixture, precools the pure solvent of the second solvent stream. On the other side the wash-filtrate of the first stage precools the first solvent stream and the two filtrates join together and precool the distilled solvent returning to the solvent storage tank. The filters are of the usual type of drum vacuum filter. The automatic valve is built in the shell. This arrangement facilitates the construction and avoids losses of solvent and of refrigeration.

A sliding vane rotary blower produces the vacuum (20 inches Hg) and compresses the air to 10 psig. for the removement of the wax cake from the filter drums. The compressed air is cooled by water and ammonia.

The solution entering in the first evaporator consists of about 1 part of oil and 6 to 8 parts of solvent. The mixture leaving the second evaporator is composed of about 1 part of oil and 1 part of solvent. The following distilling tower operates under atmospheric pressure and is fitted with Raschig rings and heated by steam of 220 psig. The oil leaves the tower with about 5 percent solvent and is finally steam stripped.

The wax solvent mixture, consisting of about 1 part wax and 10 parts of solvent is first evaporated in a vertical evaporator with five compartments. The four higher compartments are heated by exhaust steam while the lower compartment by 220 psig steam and the wax is finally steam stripped.

In order to prevent the possibility of changes in the composition of the distilled solvent because of the different conditions existing in the several stages, all liquefied solvents are mixed, during the cooling operations and return in one stream to the storage tank.

The solvent vapors are cooled by preheating the oil-solvent mixture and by water coolers in a manner to obtain the maximum saving in steam and refrigeration. The vapors from the strippers are treated separately in a system of separators and fractionator in order to drive out the water. The dehydrated solvent, before entering in the solvent storage tank, passes through a final separator to leave the last drops of water. The air leaving the plant, although its amount is very small, is ammonia cooled and passes a three-stage absorbing tower filled with oil which is renewed from time to time.

The plant was constructed seven years ago and is running now about 350 days annually. It has an average capacity of 200 barrels per day. The oils treated are usually all kinds of distillates ranging from spindle to cylinder oils produced in the Elbyn refinery from reduced crudes of Middle East origin. Distillates from crudes of other origins such as Venezuela, Russia, Rumania, etc. have also been treated without difficulties.

The simplicity of the plant is evident from the fact that only two men are needed for its supervision. With the exception of the instruments controlling the flow of ammonia and a few level controllers, there are no other instruments necessary to control pressure or temperature.

The pour point of the dewaxed oil is the same as the temperature of filtration. Waxes produced are practically free of oil. Refined paraffin waxes from spindle oil and light oil have a melting point of 125-130 F. Ceresin waxes obtained from heavier oils have melting points up to 150 F. Average loss of the solvent is less than 0.4 percent on the charge oil.

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About the Author

ANAST. S. KONSTAS received his Ph.D. degree in chemistry from Athens University in Greece. He started his career in the oil and fat industry and entered in the lubricating oil industry at the Elbyn refinery 20 years ago. He has spent 38 years in research, development, design, construction and operation of various plants in his country. Dr. Konstas is a member of the American Chemical Society and fellow of the English Institute of Petroleum.

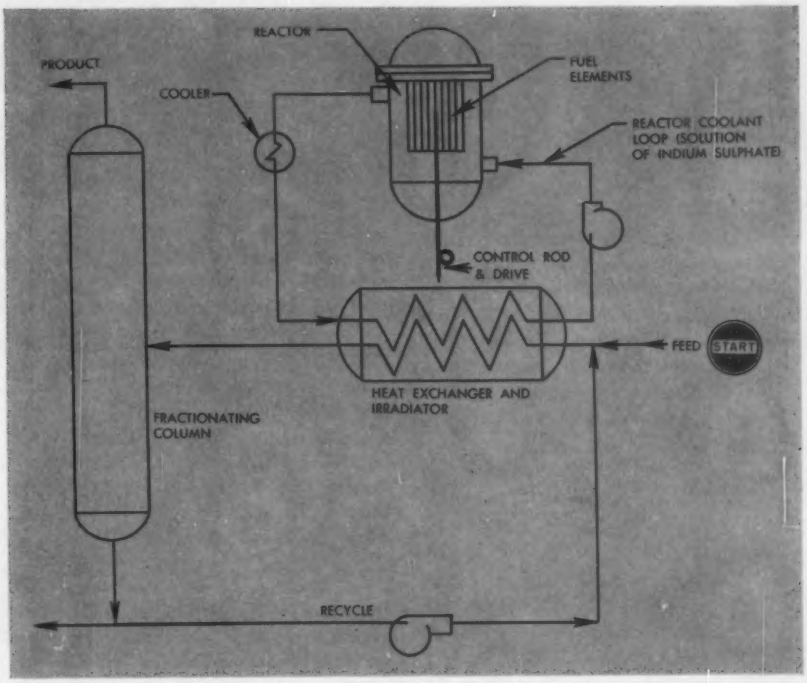

FIGURE 1—A feed stock could be simultaneously heated and exposed to gamma radiation in this petroleum cracking process.

Nuclear Reactors Seen as Process Tool

Here are some of the attributes of nuclear reactors and some possibilities for using the reactor in petroleum processing.

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Whittier, Calif.

IN ORDER to gain some appreciation of the potentialities of nuclear reactors, let us consider the reactor products.

The development of nuclear reactors in the U. S. is proceeding at a rapid pace. The Atomic Energy Commission is developing various nuclear power reactor systems in its own facilities and is contributing heavily to privately sponsored reactor developments. Most of the reactors under development, both here and abroad, are aimed at the generation of electrical energy, however, and little serious consideration has been given to reactors as process tools.

The reasons for this are as one might guess, both technical and economic. In view of the unfamiliar operational and maintenance problems introduced by nuclear reactors, strong economic incentives must be present before a process industry will accept them. The fact that at the present no reactors are being used in the process industries, or even seriously proposed, is ample evidence that these incentives have not been found.

Why should the petroleum and petrochemical industries be interested in reactor development? The exciting answer to this question is that radiation can induce changes and promote reactions in chemical compounds impossible to accomplish in any other manner. Besides performing all of the petroleum cracking reactions presently done thermally and catalytically, radiation is capable of inducing certain halogenation reactions never before observed. The effects of radiation on chemical reactions have only begun to be explored but it seems certain that such a unique and powerful tool will eventually find widespread use in the process industries.

WHAT REACTORS CAN FURNISH

In the reactor core, neutrons cause the fission of fuel atoms and during the fission process, other neutrons are released to continue the chain reaction. During the fission process, a small amount of matter is converted

into energy which appears as kinetic energy of the fission fragments and radiative energy in the form of gamma rays.

With the exception of the gamma rays and the neutrons, all of the fission products are stopped in a few thousandths of an inch and their kinetic energy is converted to heat. This heat represents about 80 percent of the energy released per fission. The neutrons travel much farther, but essentially all of them are stopped in the reactor core. The gamma rays, however, are very penetrating and a large fraction of those generated escape from the core.

Some of the energy released in fission appears as excitation energy in the fission fragments. This energy is subsequently released, usually in the form of beta and gamma radiation, depending upon the specific fission product. In general, then, operation of a nuclear reactor produces:

a. Heat
b. Neutrons.
c. Gamma Radiation
d. Radioactive Fission Products.

Thermal energy is used in large quantities by many industries and since most of the energy derived from the fission process is converted to heat within the reactor core, it would seem that exploitation of the reactor heat should precede the others. A comparison of the cost of thermal energy derived from nuclear reactors with that from conventional fuels shows that they are practically the same. Any advantage of one over the other is due to local situations such as fuel transportation charges or the temperature at which the heat is generated.

In view of the marginal cost difference, it is clear that the only industries which would be interested in nuclear reactors as sources of thermal energy would be those which produce a product whose selling price is largely determined by the cost of thermal energy consumed in its manufacture. The electric power industry is an example of such an industry. The cost of the thermal energy represents about 50 percent of the total generation cost of a kilowatt-hour of electric energy. This is not the case in other industries, however. Some of the other reactor products must prove useful in order to justify a process reactor. If the use of a reactor could be justified on some other grounds, the reactor heat would, of course, be used in the process as efficiently as possible.

Neutrons can be used to no particular advantage in most process industries, because of neutron activation. A neutron, being uncharged, can easily approach the positively charged nucleus of an atom close enough to be absorbed, converting the atom into a different isotope. The new isotope is usually formed in an excited state and is therefore radioactive. Even if the particular material being processed is not subject to neutron activation, it would invariably contain traces of impurities which would become radioactive, yielding an undesirable product.

Gamma radiation, on the other hand, is capable of breaking and rearranging molecular bonds without causing undesirable activation. This radiation will undoubtedly find eventual large scale use in many processes, including the petroleum refining field. In fact, gamma cracking of petroleum is currently under intensive investigation by most of the major oil producers, but very little quantitative data are available outside these laboratories.

Reactor core gammas can be used directly by circulating the material to be exposed to the gamma flux outside the core with a neutron absorber, such as borated water, interposed between the core and the material being processed. This method would prevent neutron activation without seriously attenuating the gamma flux. Another method of using direct core radiation would be to circulate an easily activated material such as a solution of indium sulphate through the core (or around it) and then to an external "radiator." This scheme has been proposed for the Food Irradiation Reactor.[1]

The fission products, as mentioned above, can be used as a source of high energy gamma rays and if it turns out that such a source is intense enough for commercial purposes, the need for an on-site reactor will be eliminated. This would indeed be fortunate, not only for the process industries, which would then not have to build and operate reactors, but also for the owners of reactors who would then have a valuable by-product to sell.

Let us assume, for the moment, that the use of a nuclear reactor in a petroleum refinery can be justified on economic grounds and concern ourselves with the problems of procuring, operating and maintaining the device.

HOW TO GET A REACTOR

It will be many years before nuclear reactors become standardized to the extent that pumps, turbines, boilers and other conventional equipment have become. Each reactor will be tailor made for the particular job in mind so that proportionately greater design and engineering effort will go into a reactor installation than into most conventional plants.

The selection of the reactor type will also depend upon many factors not dictated by the process. The relative advantages of one reactor type over another, in regard to safety, turnaround time, operating characteristics and cost are a long way from being decided. Not enough reactors have been built and operated to realistically evaluate the various reactor systems.

There are many excellent reviews available[2] describing the various reactor types and no attempt will be made here to duplicate such material. In general, however, it may be said that reactor core design involves a great many compromises between the demands of the nuclear, heat transfer, structural and chemical-reprocessing characteristics. For example, easily fabricated and reprocessed fuel elements do not usually have a long life in the reactor core and must be reprocessed and refabricated often, thus defeating the original intention. Other examples include incompatibilities between coolant flow velocities and fuel element spacing as dictated by heat transfer and nuclear physics considerations. One of the major compromises that must be made, particularly in aqueous systems, is between the coolant temperature and pressure and the size of the pressure vessel. Assuming that the reactor type has been selected and design is underway, the next step in reactor procurement is to satisfy all of the necessary legal requirements.

Under present law, no person or persons may build a nuclear reactor in the U. S. until they have obtained a construction permit from the

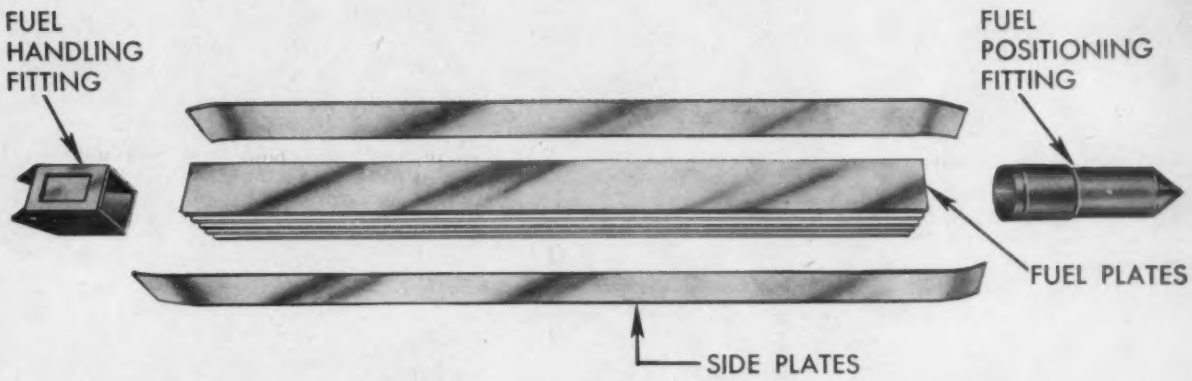

FIGURE 2—Stainless steel clad fuel plates are grouped together into assemblies called fuel elements.

Atomic Energy Commission. In the absence of any request for financial or material assistance from the AEC, the decision to grant the license will be based primarily on the safety aspects of the reactor installation and its relationship to its environment. There exists a good deal of precedent, in this connection, established by the utility companies who are planning to install nuclear reactors. Nevertheless, each proposed reactor installation is examined in detail by the AEC's Advisory Committee on Reactor Safeguards and the AEC's action is generally based upon the committee's recommendations. The committee is primarily concerned with three questions:

1. What is the probability that large quantities of radioactive fission products will escape from the reactor system?
2. Assuming the reactor system has ruptured, how effectively is the radioactivity confined to the reactor site?
3. Assuming the radioactivity has been released to the atmosphere, and, considering the local climatology and population distribution, to what extent will the surrounding populace suffer as a result of the radioactivity?

After the construction permit has been secured and the plant built, the operator must obtain an operator's license before he can activate the reactor. In order to qualify for this license, the operator must prove to the satisfaction of the AEC that he is competent to operate the reactor and to deal with any emergency situations that might arise. In addition he must show that he has employed people qualified in the field of radiation protection and reactor operation. He must also submit a detailed plan for starting the reactor and for operating it under all conceivable conditions.

During construction of the reactor, the operator will have applied for a license to receive sufficient fuel material to load the reactor. In order to qualify for this license he must submit a detailed fuel accountability plan which will permit an accurate fuel inventory to be made when the fuel is in the hands of the fabricator, in the reactor, in storage, or in the chemical reprocessing plant. He must anticipate the losses in fabrication and the number of excess fuel elements he will need in the fuel cycle.

It should thus be obvious that the procurement of a nuclear reactor is considerably more involved than is the case of conventional process components. Presumably, the licensing procedures will be simplified in the future as the routine becomes established and more experience is gained.

HOW THEY MAY OPERATE

Figure 1 is a highly schematic diagram of a technically feasible method of using a nuclear reactor in a petroleum cracking process. The feed, mixed with the recycle, is pumped through the "irradiator" to the fractionating column. In the irradiator the feed stock is simultaneously heated by the hot indium sulfate solution (reactor coolant) and exposed to the decay gamma radiation from the solution. The reactor heat picked up by the gas oil is used as distillation heat while the gamma flux increases the light fraction yield by molecular cracking.

One of the advantages of gamma cracking is that radiation interacts with individual molecules and does not, for instance, raise the temperature of the bulk material. This means that certain molecular changes can be effected by radiation which would be impossible to do thermally because the high temperature required would destroy the material being treated.

Since both heat and gamma energy are directly proportional to the reactor power, it would be rather remarkable if the radiation requirements coincided with the thermal requirements of the process. As previously mentioned, the most valuable reactor product, from a process standpoint, will probably be gamma radiation rather than thermal energy since the thermal energy is only marginally competitive with that obtained from fossil fuels. It is, therefore, impossible to estimate the reactor power level from the thermal requirements of the process alone.

An order of magnitude estimate might be made by computing the number of molecular bonds to be broken per unit of time, multiplying this by the energy required to break the bond and equating this figure to the required gamma energy. After applying an efficiency factor (to account for excess energy per gamma and absorptions which do not result in bond rupture) an estimate could be made of the power level of the reactor.

Because of the uncertainties involved in this type of calculation, it is felt that the result would be more misleading than informative. When the gamma flux required for a particular process has been established, the reactor power level necessary to generate this flux can be computed. Unfortunately, these flux levels have not been determined so that it is presently

impossible to size the reactor from radiative energy requirements.

In order to balance any mismatch between thermal and radiative energy requirements, a cooler is shown in the reactor coolant loop. In practice, this cooler would be incorporated into the over-all heat balance of the plant.

The reactor shown in Figure 1 is a heterogeneous type. (A heterogeneous reactor is distinguished from a homogeneous reactor in that the fuel and moderator are separated in the heterogeneous type, mixed in the homogeneous type.) It has stainless steel clad fuel plates grouped into assemblies called fuel elements, similar to those shown in Figure 2. The assemblies are arranged and rigidly supported in a pattern (see Figure 3) which forms the reactor core. The coolant solution circulates between the plates of the fuel elements, acting both as a neutron moderator and heat removal medium.

The entire core assembly is enclosed in a pressure vessel operating at sufficient pressure to prevent boiling of the reactor coolant. The physical size of the reactor core depends upon many considerations but is perhaps in the form of a cylinder six feet in diameter and six feet high. It will contain about two hundred fuel elements and ten control rods.

The control characteristics of a nuclear reactor differs in several important respects from those of more conventional devices. In order to appreciate this one must have an understanding of what is meant by "criticality" or a reactor in the critical state.

As an analogy that may help in understanding this concept, we might think of a reactor genetically, in which case the neutrons represent members of a population. Each neutron follows a life cycle in which it is born, diffuses through the core and then dies.

The death of a neutron, as far as the reactor is concerned, may occur in two ways—leakage out of the core or absorption within the core. Leakage is reduced by placing a reflector around the core, but, inevitable, some neutrons leak through the reflector or are absorbed in it and these neutrons are completely lost from the reactor core neutron population. This sequence is not true of the neutrons that are absorbed in the core, however, because some of the neutrons are absorbed by uranium and lead to fission, thus giving birth to new, next generation, neutrons.

One then can speak of an average neutron, and this average neutron has an average life span and at death produces a certain number of offspring. If the average neutron produces on the average of one neutron when it dies, we say that the reactor is critical because the second generation will contain just as many neutrons as the first generation and the same will hold for all succeeding generations.

The ratio of the number of neutrons in the second generation to the number of neutrons in the first generation is called the multiplication factor for the reactor. In a critical system the multiplication factor equals precisely unity.

Each neutron lifetime, approximately one ten-thousandth of a second, the neutron population is multiplied by the multiplication factor. Since the power level of a nuclear reactor is directly proportional to the neutron population, we can control the power level by controlling the multiplication factor. And, because the multiplication factor is applied so often, a small change in it causes a relatively rapid change in the power level.

Ordinarily, the multiplication constant is varied by changing the amount of neutron absorber in the core. This absorbing material, boron, cadmium, or hafnium, is in the form of a rod that can be inserted or withdrawn from the core. There is one position of this rod for which the reactor is just critical. If the rod is withdrawn, the multiplication factor will be greater than unity and the power level or neutron population, will grow. If the rod is pushed further into the core, the power level will decrease. When the desired new power level is reached, the rod is returned to its original position and the new power level will be maintained.

The above discussion refers to the minute-by-minute type of reactor control. There are long-term control problems that result from fuel burnup. As the fuel is consumed, the multiplication constant decreases until the reactor is no longer critical, even with the control rod pulled all the way out. In order to extend the time between shutdowns, considerably more fuel is put into the reactor than is required to reach criticality initially. The effect of this excess fuel is countered by inserting absorber rods, called shim rods. As the fuel is depleted, the shim rods are periodically withdrawn to restore criticality; this operation is called "shimming the reactor."

Another control characteristic of reactors which should be mentioned is the effect of temperature on the multiplication constant. As the temperature of the core increases, the core expands, making it easier for neutrons to leak out because of the reduced core density. The result is that a temperature rise tends to shut down the reactor while a drop in temperature tends to increase the power level. This characteristic, known as the negative temperature coefficient of reactivity, tends to make reactors self-regulating and has been successfully demonstrated with several reactor systems.

This tendency of a reactor to maintain a constant temperature should greatly simplify the process control of a system using a reactor. For instance, in the scheme presented in Figure 1, the outlet temperature of the gas oil from the heat exchanger would remain substantially constant even though the flow rate varied. Each barrel of feed would then be heated to the same temperature and exposed to the same amount of radiation, regardless of the flow rate. Very good product control should result from such a system.

CONSIDER ACCIDENTS AND MAINTENANCE

A "nuclear incident," or accident, is something generally related in the public's mind to an atom bomb explosion. As a result, nuclear reactors are held in considerable fear by the average man. He envisions a very delicately balanced mechanism in which the slightest misoperation can lead to a full-scale explosion. This, of course, is not true. Nevertheless, a reactor must be considered a potentially dangerous machine.

In the first place, a nuclear reactor

inherently cannot explode with anything like the force of an atom bomb. We have already discussed the temperature-limiting effects of the negative temperature coefficient of reactivity. If all of the control and shim rods are removed instantaneously (an obvious impossibility), the reactor power will rise rapidly, overheating the core until it becomes subcritical. This occurrence is generally referred to as a thermal burst—no substantial shock waves are set up, but the intense heat will probably melt the reactor fuel elements. If the reactor is cooled by a liquid, the liquid in contact with the core will probably vaporize and result in a rupture of the coolant system. A sequence of improbable events in which the fuel elements are melted, followed by a rupture of the coolant system, constitutes the maximum catastrophe a reactor can suffer.

Under these conditions, millions of curies of radiation in solid, liquid and gaseous forms are released to the reactor building. If the reactor had been operating for a considerable time before the incident, the radioactive fission products released would be sufficient to contaminate the air and water for hundreds of square miles around the plant. As one can see, under these conditions the third party liability claims could be enormous.

For this reason, the concept of ultimate containment has become a part of most reactor designs. The reactor and the entire coolant loop are placed in a gas-tight building sufficiently strong to withstand the maximum pressure pulse expected if the coolant system ruptures. Naturally, the building itself would become untenable, but the radioactivity would be confined to the building with no possibility of injuring anyone outside the reactor site. The operators within the building at the time of the accident would probably have to be considered expendable, but again, let us emphasize that we are referring to the maximum credible accident: that one chance in perhaps a billion that all of the unlikely and careless events necessary to precipitate this incident have occurred in proper sequence. Even so, reactor designers are striving to devise fuel elements that, even when melted, retain the fission products within the molten mass.

It is doubtful that any of the reactor could be salvaged or repaired following an accident such as described. However, the situation is not much different from a serious explosion and fire in a petroleum refinery.

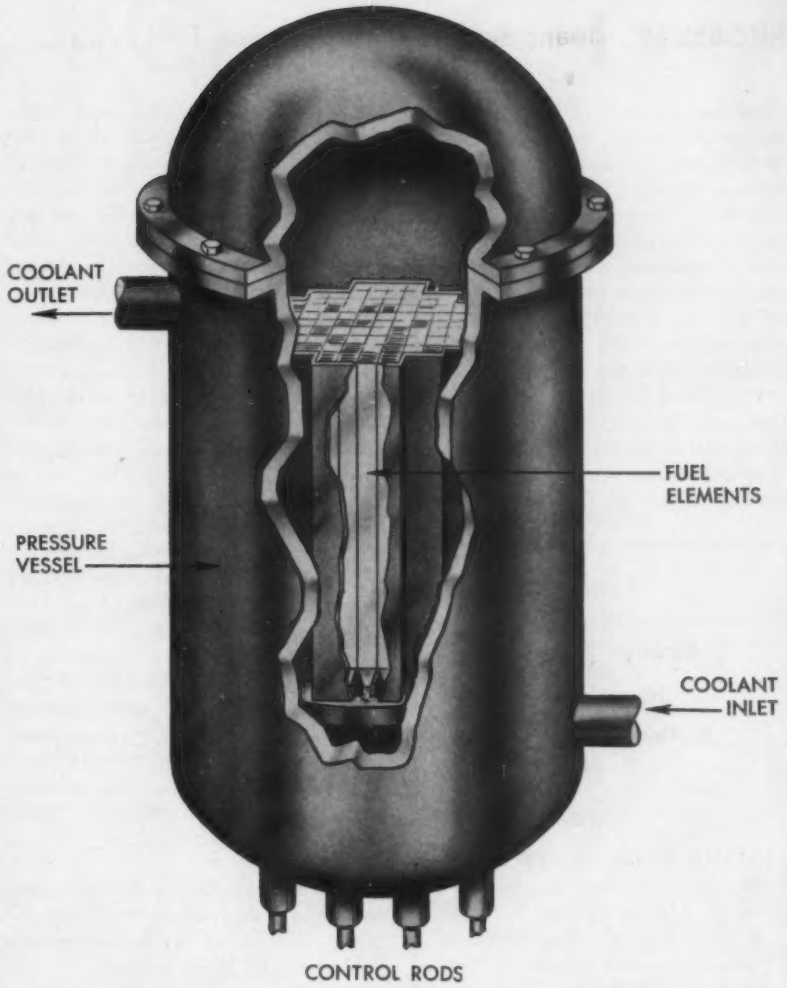

FIGURE 3—The coolant solution circulates between the plates of the fuel elements, acting both as a neutron moderator and heat removal medium.

To return to the more likely accidents, there are two general categories that merit discussion. The first is the discovery of radioactivity in the coolant. In this case, the reactor is immediately shut down and the activity analyzed to determine its origin. It may arise from a defective fuel element or from some impurity in the coolant that was activated by the neutron flux in the core. If the activity was caused by an impurity, it is a simple matter to purge the reactor system, locate and remove the source of the contamination.

On the other hand, a defective fuel element requires a longer shutdown and might mean replacing the entire core. Some reactors have been built incorporating fuel element monitoring systems which would greatly simplify the repair operation. Unfortunately, these monitoring systems have not been very successful in the past and generally are difficult to keep in working order.

From an operating standpoint, it would probably be sounder to replace the entire core and get the reactor back on stream as soon as possible. Then the fuel elements could be examined individually (through about twenty feet of shielding water or in a hot lab) to find the defective unit. The remaining partly used elements would be scheduled for reinsertion with future new elements.

The second general category of accidents deals with the failure of

some part or parts of the mechanical system. All of the components should be designed and installed with maintenance in mind. This is usually the case in conventional plants, of course, but because of the added complication of radiation and equipment contamination much more thought must go into the placement and arrangement of the mechanical auxiliaries of a nuclear reactor.

For one thing, all of the surfaces that may become flooded with contaminated fluids must be coated with a smooth, impervious coating. This coating allows the contamination to be washed and scrubbed away without destruction or removal of the structural surface beneath it. Several commercial plastic coatings suitable for this service are available and are in extensive use at the present time.

It is often convenient to locate pumps and valves in pits that may be flooded with water, in case maintenance is necessary. Here the water acts as a transparent shield and even though it is awkward to work with long-handled tools through several feet of water, the job can be accomplished in a shorter time than is possible with direct maintenance. Without the water shield, a man might receive his allowable weekly radiation dose in a few minutes, and would then have to be replaced. One can rapidly run out of men on such an operation.

The rupture of the reactor coolant piping would release a large quantity of low-level radioactivity throughout the area. Again, it is essential that all of the exposed building surfaces be coated to permit thorough cleaning and decontamination.

Waste Disposal. The contaminated coolant and wash solutions are usually stored in shielded (or underground) hold-up tanks. Here, the radioactivity is allowed to decay to a safe level, after which the coolant may be returned to the system, or discarded. If the radioactivity is composed primarily of long lived fission products, some type of concentration is usually employed and the residue buried. Common concentration methods include distillation, chemical precipitation, and calcination.

The used, radioactive fuel elements are not considered waste products, since they still contain most of the original fissionable material. These elements are allowed to cool for a period about equal to the time they had spent in the reactor and are then placed in lead containers for shipment to a chemical reprocessing plant. These lead containers, sometimes called "coffins," weigh from twenty to one hundred times as much as the fuel elements, depending on how long they were in the reactor and how long they were cooled. The transportation costs involved in shipping these containers are not negligible items, especially since the coffins must make round trips.

Health Physics. Because of the insidious nature of radiation, an entirely new branch of health and safety control, called Health Physics, has grown up with nuclear reactors. It is the purpose and responsibility of this group to monitor and survey working areas to determine the amount of radiation existing in all occupied areas around the plant. The remarkable radiation safety record at AEC installations is due in a large part to the vigilance of this group.

In order to be effective, the health physicists are given absolute authority in determining working conditions and exposure times. They are the first people to enter a contaminated area and, after completing the radiation survey, they determine the allowable time a man may safely work in the area.

In addition to this emergency sort of action, the Health Physicists group is in charge of the radiation exposure meter or film badge operation at the plant. These meters or badges are worn by all employees while they are in the plant and the meters indicate the total radiation to which they have been exposed. The meters are read every day or so and a cumulative total radiation dose is tabulated for each employee. In some cases, when a man has received nearly the allowable radiation dose, he is transferred to a work area that has a lower radiation field.

In summary, the operation of a nuclear reactor plant to a large extent is similar to the operation of a conventional thermochemical plant. Procurement, because of legal requirements and lack of technological experience, is complicated and maintenance techniques are totally different from those used in conventional plants.

It seems certain, despite these complications, that nuclear reactors will eventually become a major tool of the process industries. The day is not too far off when our automobiles will be powered by gamma-cracked gasoline, upholstered with radiation stabilized polyethylene fabric and fitted with gamma-vulcanized tires.

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[2] Charpie, R. A., et al., PROGRESS IN NUCLEAR ENERGY, Vol. II, McGraw-Hill, 1956.

About the Author

MARK R. DUSBABEK, senior research engineer with Fluor Corp., Ltd., graduated from the University of Minnesota, in 1950 with a B.S. degree, in electrical engineering. Following graduation he worked for Pfeifer & Shultz, and C. F. Braun and Co. designing power electrical distribution systems.

In 1952 he was awarded a scholarship from the AEC to attend the Oak Ridge School of Reactor Technology. While there he prepared a report on the nuclear design of a high temperature power reactor. This design report was issued as a classified document by the Atomic Energy Commission. Upon graduation from the Oak Ridge School of Reactor Technology in 1953, he joined Fluor where he is responsible for the nuclear design of research and power reactors. Dusbabek is a member of the American Institute of Electrical Engineers, the Nuclear Engineering Division of AIChE, and the American Nuclear Society.

PROCESS DESIGN PRIMER

- Where process design starts and ends
- How to take the first steps in design
- How to estimate plant costs and profits

Frank C. Fowler
Consulting Chemical Engineer
Kansas City, Missouri

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265 Instrumentation: It Needs Attention

for the . . .

- **New Process Engineer**
- **Chemist**
- **Mechanical Engineer**
- **Rusty Chemical Engineer**

So many in the act?

Yes, there's no doubt that the trend in the industry has been toward more people involved in process design. This is because processing involves so many variables and continues to get more complex. But there's no reason you need be left out; because even though there are process design specialists, the mechanical engineer, chemist and new process engineer can catch up.

That's what this special report will help you do. It will help you know what is being done and what calculations you can make with confidence. This is the way to take your first big step into process design.

PROCESS DESIGN is that phase of engineering which selects the processing steps and determines the proper temperatures, pressures, flow rates and over-all dimensions of the equipment. From this information an estimate of the plant investment can be made. An estimate of the operating cost when combined with a knowledge of the plant investment provides sufficient information to determine the unit cost of manufacturing the product.

Evaluation of a new project starts with the preliminary process design. If this preliminary design shows the project to be promising, additional process designs are made at intervals during the development of a final plant design. Before the final detailed equipment designs can be started, the final detailed process design must be completed.

The cost of the process engineering varies from 5 to 30 percent of the total engineering cost. An average for the petroleum industry would be close to 20 percent. When the engineering budget for a project is trimmed, it is the process design which generally is neglected. Reducing the amount of process engineering to a bare minimum seldom results in a faulty design; but the plant investment and the cost of operation may be considerably higher than is necessary.

The object here is to extend the use of process design to engineers who are not specialists in the field. It is not necessary to qualify as a specialist in the field to derive the benefits of good sound process engineering. Before 1940, cost data were not available in the literature and it was necessary for the process engineer to develop his own sources of information. Now the situation is reversed and it is difficult to decide which information should be used.

Another objective is to present a compilation of cost data and other information which make a complete process design primer. Heretofore, articles published on cost data have not seen fit to explain the other phases of process design. An engineer who engages in process design soon recognizes the need for keeping an up-to-date process file.

Results of Process Design. Sound process engineering can result in the following benefits:

1. Lower plant investment
2. Lower operating costs
3. Lower maintenance cost

The proper design will depend upon the particular problem. For example, to achieve the minimum unit cost for a product does not mean that the plant investment or operating cost will also be at a minimum. For companies with adequate capital, the minimum unit cost can be more important than minimum plant investment. When considering a design for a company with limited capital, it is more desirable to design for low capital requirements.

Careful selection of processing steps and equipment can make a given plant easier to operate and maintain. For example, selection of moderate water-exit temperatures from heat exchangers will reduce their cleaning requirements. Such practices result in less downtime and lower water treating costs. In this phase of process engineering, the experienced process engineer has the edge over the beginner.

A number of companies, in a recent survey, expressed a lack of proper application of instrumentation from a process point of view. Because of his knowledge of the effect of the variables, temperatures, pressure and flow rate on the process, the process engineer is in an excellent position to specify the most suitable methods of instrumentation.

The applications of process engineering are so numerous and varied (instrumentation to economics) that even the seasoned engineer never reaches the point where he is satisfied with his knowledge in the field. By reason of their academic training, chemical engineers are best suited for process engineering. However, many mechanical engineers and chemists are successfully engaged in the profession. Any engineer or chemist who possesses the interest can perform preliminary process design calculations with a great deal of satisfaction.

Problems encountered by process engineers fall into two types. Most common is the design of the unit to produce a given product. This problem requires an estimate of the plant investment and operating costs so that the unit cost of manufacturing the product can be computed. For an established product, the selling price is

well defined so that when the unit cost of manufacturing the product is known, the profit or payout for the project can be predicted. For a new product, an estimate must be made of the selling price before a prediction of the economic success of the process can be determined.

Another type of problem deals with predicting the most desirable products that an existing unit is capable of manufacturing for a maximum return.[1] Any existing refinery and petroleum market presents the opportunity for studies of this nature.

In evaluating a new process, these steps are generally carried out in the order listed:

1. Prepare a material balance
2. Prepare a heat balance
3. Determine the over-all dimensions of major equipment
4. Estimate plant investment
5. Compute the unit cost of production

Most engineers or chemists are able to carry out Steps 1 and 2. Steps 3, 4 and 5 present more difficulty for those not familiar with the field.

In the development of new processes, frequent process design of increasing accuracies are necessary. Failure to review the process design at frequent stages during the development of the project, has placed management in embarrassing situations. Projects have been carried through construction stages and then abandoned when it became evident that up-to-date evaluations no longer showed the project economical. In years of inflation, rising construction costs increase the necessity of making frequent cost estimates. New developments make standard processes obsolete in a relatively short time. This is one of the reasons that many new processes must show a payout of less than three years before capital can be attracted.

About the Author

FRANK C. FOWLER opened his office as a consulting engineer in 1951 in Kansas City where he has been concerned mostly with process design in the petroleum field. During this time he has also been a petroleum consultant for Midwest Research Institute in Kansas City. Fowler received his B.S. degree in chemical engineering from the University of Illinois, and his M.S. degree in 1940 and his Ph.D degree in 1943, both in chemical engineering from the University of Michigan. In 1943 he joined Phillips Petroleum Co., Bartlesville, then in 1946 he went to the University of Oklahoma, Norman, as a professor of chemical engineering where he remained until 1951.

Research and development groups can frequently profit from preliminary process design evaluations of their new processes. When carried out in early stages of the development, the process design evaluation often points out the critical variables from an economic standpoint. Sometimes research and development costs can be reduced appreciably. The more complicated processes offer the greater chance of saving time and money in the research and development programs.

Flowsheets: How to Draw Them

Flowsheets can be considered the trademark of process engineering. They indicate the completion of one phase of process design and offer the opportunity to summarize a great deal of information in one place. The old adage that "a picture is worth a thousand words" is particularly true of flowsheets. A better idea of the over-all process can be obtained by glancing at a flowsheet than can be gained by reading pages of description.

Despite the fact that the flowsheet is the end product of process design, little information on its real objectives has been presented.[2]

A good flowsheet should require a minimum of time to review. It should not be constructed on the same basis as a crossword puzzle—to test the ability of the reader. Keeping the following paramount points in mind should help in its preparation:

1. Provide orderly flow of material through process (left to right)
2. Reduce crossing of flow lines to a minimum
3. Avoid crowding of information

Many flowsheets are constructed by individuals who are too conscious of the space relationships of the actual equipment. For example, many place all major equipment on the same base line. This often makes it difficult to achieve the three objectives listed above. To illustrate the point under discussion, Figures 1 and 2 are presented. Upon examining these figures, it is obvious that it is much easier to follow the process in Figure 2. Figure 1 is handicapped because the equipment has been placed on the same base line. Notice the difficulty of following the flow lines in Figure 1 and the ease of tracing the flow pattern in Figure 2.

In considering a process flowsheet, the most important item is the sequence of the operations involved. Specifications of the equipment is of secondary importance. Three possible styles of constructing flowsheets are:

1. With equipment lines and flow lines of the same weight
2. With equipment lines heavier

Figures 1 through 5 on following two pages ▶

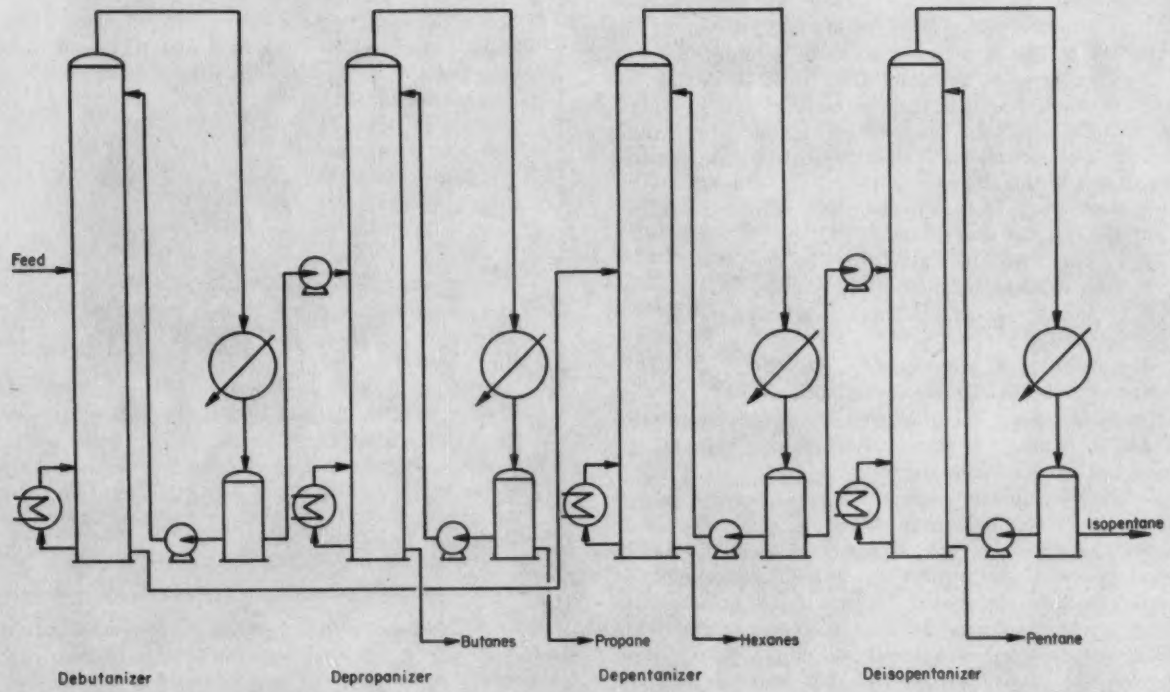
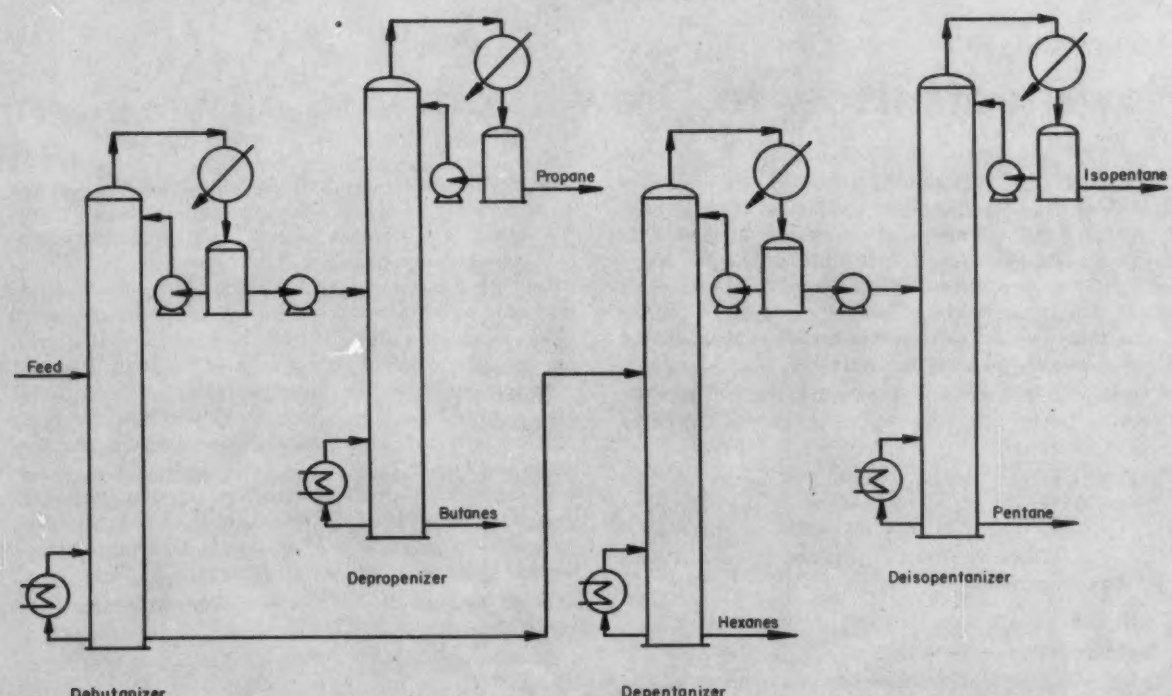


FIGURE 1—*Flowsheet drawn with all major equipment on a base line. It's harder to follow than . . .* **FIGURE 2** *. . .*



Flowsheet drawn without reference to a base line. It's best way to get orderly sequence.

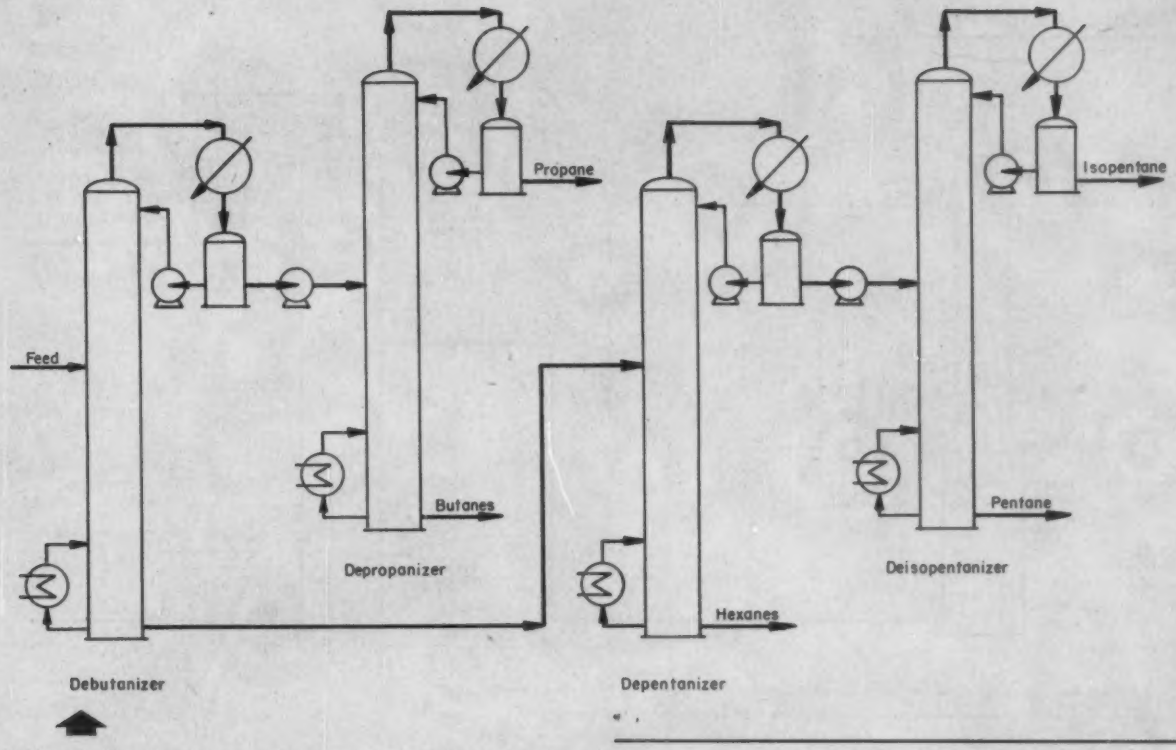


FIGURE 3—*Flowsheet drawn with flow lines heavier than equipment lines.*

Editor's Note: The equipment symbols proposed by Mr. Fowler are similar to the standards which Petroleum REFINER has used fo rthe past three years.

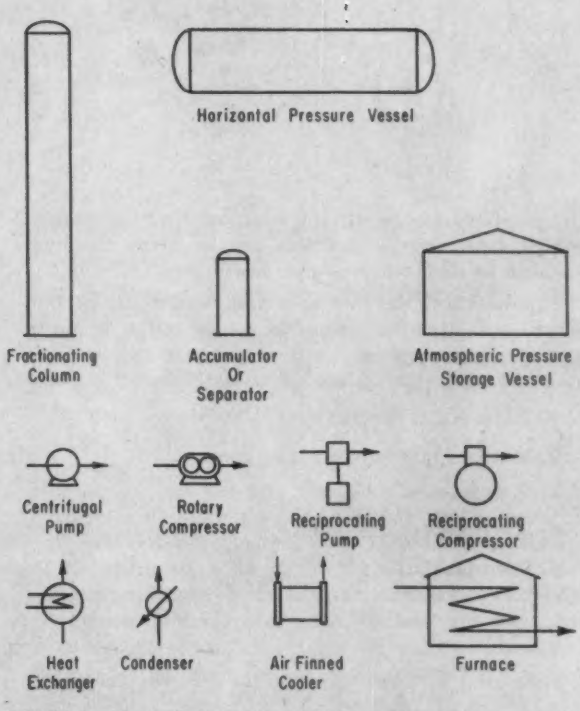


FIGURE 4—*Symbols for major equipment: Templates are available to make it easy.*

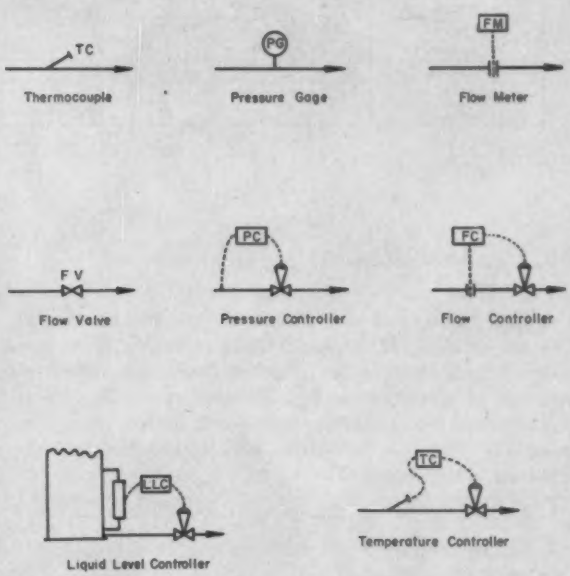
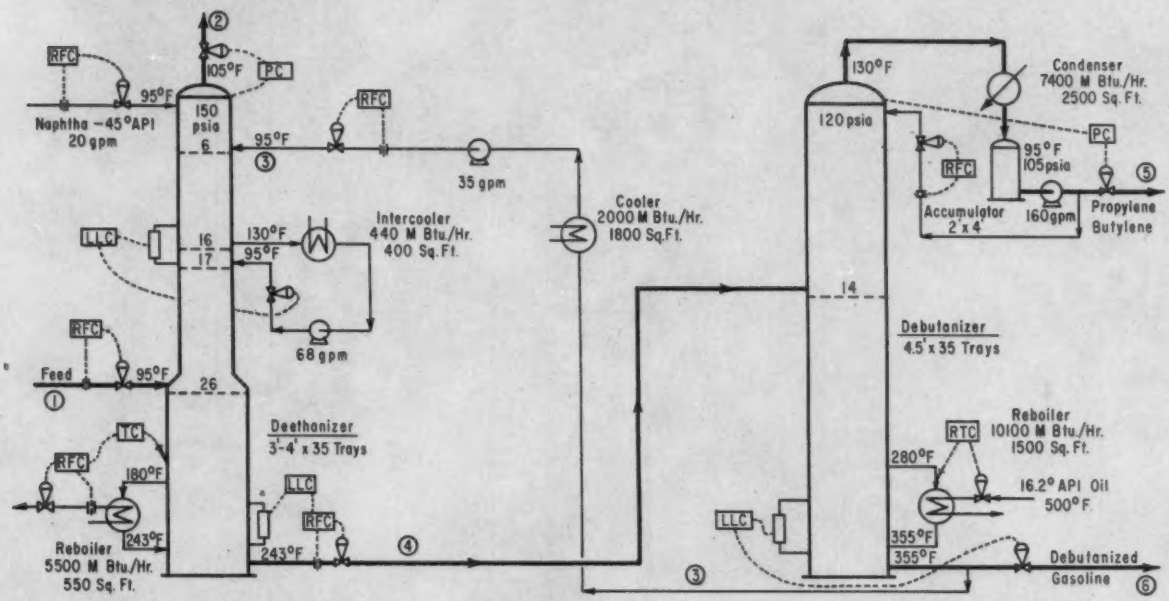


FIGURE 5—*Symbols for instrumentation: It pays to standardize.*



Stream No.	①	②	③	④	⑤	⑥
Composition – Mol %						
Hydrogen	6.3	26.5				
Methane	7.8	33.6				
Ethylene	2.2	9.2		0.2	0.6	
Ethane	4.0	15.8		0.3	0.9	
Propylene	7.8	9.8		5.3	15.9	
Propane	5.9	4.9		4.6	13.8	
Butylene	6.3			6.1	18.3	
Isobutane	13.9	0.2		13.5	40.5	
N-Butane	3.6		0.5	3.5	9.5	0.5
Isopentane	6.6		12.6	8.6	0.5	12.6
N-Pentane Plus	35.6		86.9	57.9		86.9
Total Mol/Hr.	727	169	130	749	249	370
Total Gal./Min.			35	182	47	100

FIGURE 6—*Flowsheet showing way to present temperature and pressure data near equipment and flowlines; material balance is presented in block form.*

3. With flow lines heavier

Of the three possible methods, the third is generally preferred. Figure 2 is an example of Style 1, while Figure 3 is an example of Style 3. Comparison of these two figures shows that emphasizing the flow lines makes the sequence of operation easier to follow.

A standard list of symbols is desirable for use on process flowsheets. The type of symbol selected should fulfill the following conditions:

1. The symbol can be drawn with a minimum of effort

2. The appearance of the symbol suggests the equipment it represents

A reasonable compromise between these two points must be obtained to realize the best results. A list of major equipment symbols is suggested in Figure 4, and a similar list for instrumentation is presented in Figure 5. Templates are available for flowsheet drawings that meet the specifications mentioned. In addition, their convenience makes them quite a desirable aid for those frequently engaged in the preparation of flowsheets.

In addition to the flow lines and equipment, the flowsheet contains additional amounts of information, depending on whether it is a preliminary or detailed flowsheet. The information on a detailed flowsheet includes:

1. Pressure and temperatures

2. Material balance and stream compositions

3. Heat balance

4. Equipment specifications

5. Instrumentation

There are, in general, three methods of placing temperature, pressure and material balance information on a flowsheet:

1. By using various symbols for the different quantities

◀ *Figures 1 through 5 on preceding two pages*

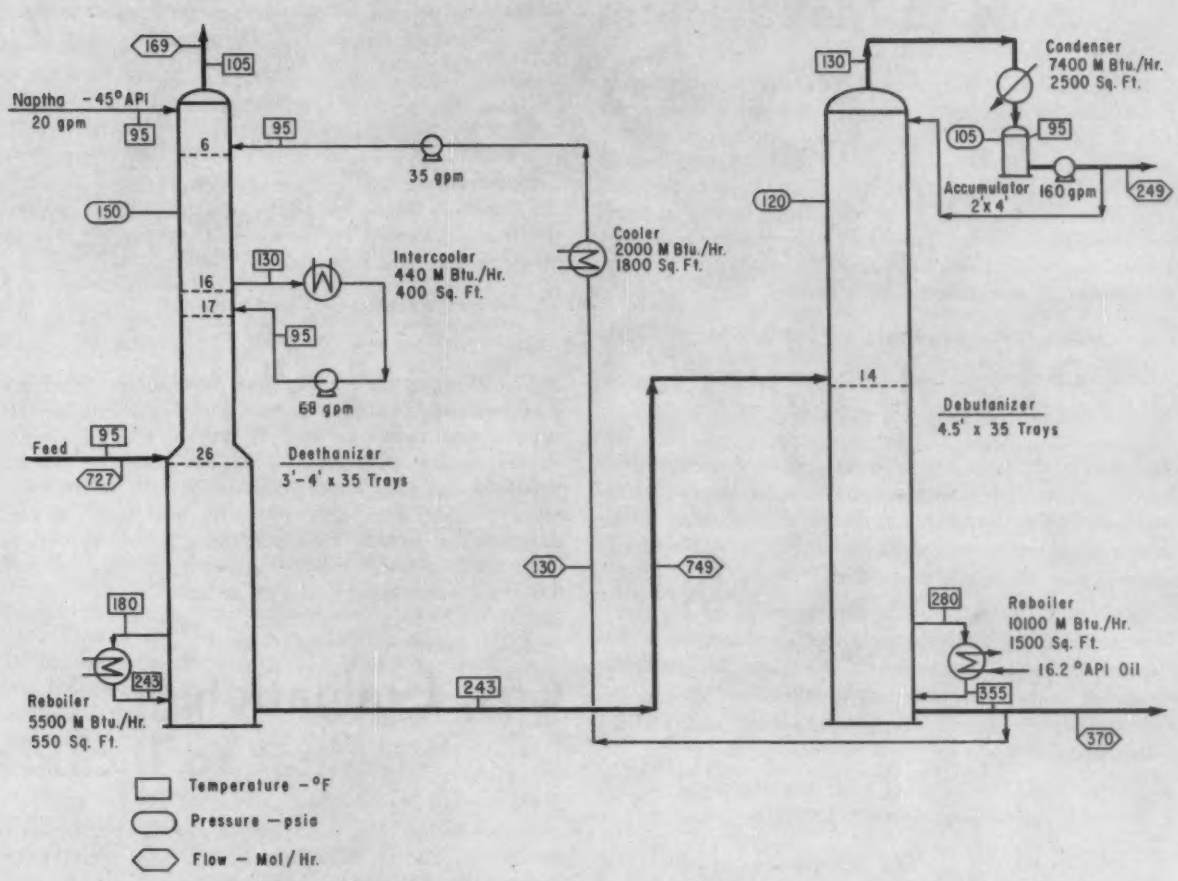


FIGURE 7—*Flowsheet with symbols for noting temperature pressure and material balance data.*

2. By locating information near the equipment or flow lines

3. By means of a block form at the bottom of a flowsheet

For economy of time in drawing, either Type 2 or 3 would be preferred over Type 1. If the amount of information needed is simply the temperature, pressure and total quantity of streams, this can be placed at the appropriate location throughout the flowsheet without detracting from the over-all flow pattern. In more detailed flowsheets, the best procedure is to use a material balance at the bottom of the drawing which gives compositions and total quantities. An example of this type of construction is shown in Figure 6. This flowsheet includes instrumentation and an extensive material balance, yet it is easily constructed and can be interpreted with a minimum of effort. It is generally worth while to draw a sketch to get the optimum arrangement of major equipment which will result in the minimum amount of crossing of flow lines. After making two or three arrangements, one arrangement will generally excel in this respect.

Figure 7 illustrates an example of Type 1 construction where symbols indicate the quantities represented. This type will not allow as much information to be presented conveniently as the block form of Type 3 (Figure 6). Instrumentation and stream compositions have not been included in Figure 7 because of the lack of space.

The preceding remarks have been directed at process flowsheets. Another flowsheet is necessary before a project has passed to the construction stage. A piping flowsheet is drawn which summaries all the piping connections, including the start-up lines, drains and bypass lines which are necessary to the successful operation of the unit. The object of this type of flowsheet is to summarize all piping and provide a starting point for piping drawings. Although this additional piping might be included on the process flowsheet, it tends to confuse the drawing and make it more difficult to obtain the necessary process information.

Continued on next page

Recycle Calculations: How to Make Them

Although few engineers have difficulty with preparing a material balance for a unit, the problems that do arise nearly always involve a recycle stream. A common recycle problem generally involves a chemical reaction which does not go to completion. For example, consider the conversion of ammonia to nitrous oxide in the manner described by Kobe and Hosman.[3] The conversion of ammonia to nitrous oxide results from the reaction of oxygen and ammonia according to the equation

$$NH_3 + O_2 = 1/2N_2O + 3/2H_2O \qquad (1)$$

A side reaction results from the following equation

$$NH_3 + 3/4O_2 = 1/2N_2 + 3/2H_2O \qquad (2)$$

Other side reactions resulting in the formation of the higher oxides can be avoided by maintaining the temperature in the proper range. From the following data, determine the ultimate yield and the ratio of the feed ammonia to the recycle ammonia:

Conversion of ammonia to nitrous oxide at the temperature and space velocity under consideration is 70 percent. Of the remaining 30 percent, 14 percent is reacted to nitrogen according to Equation (2) and 16 percent is unreacted. The percentage of ammonia in the feed is 10 percent.

Solution: Basis 100 mols of inlet gas composed of 10 mols of ammonia and 90 mols of oxygen.

Amount reacted acording to Equation (1) equals

Reacted $NH_3 = 10(0.70)$	= 7	mols
Reacted O_2	= 7	mols
Produced $N_2O = 1/2(7)$	= 3.5	mols
Produced $H_2O = 3/2(7)$	= 10.5	mols

Amount reacted according to Equation (2)

Reacted $NH_3 = 10(0.14)$	= 1.4	mols
Reacted $O_2 = 3/4(1.4)$	= 1.05	mols
Produced $N_2 = 1/2(1.4)$	= 0.7	mols
Produced $H_2O = 3/2(1.4)$	= 2.1	mols
Unreacted ammonia $= 10(0.16)$	= 1.6	mols

Material Balance Around Reactor

	Reactor Inlet			Reactor Outlet	
	Mols	Lbs		Mols	Lbs
NH_3	— 10	170	NH_3	— 1.6	27.2
O_2	— 90	2880	N_2O	— 3.5	154.0
	100	3050	H_2O	— 12.6	226.8
			N_2	— 0.7	19.6
			O_2	— 81.95	2622.4
				100.35	3050.0

Notice that the material balance was computed on both a mol and weight basis. The weight balance serves as a check. The total weight entering the reactor must equal that leaving even though the mols in and out are not usually equal. Assuming a complete separation of the unreacted ammonia in the reactor outlet, 1.6 mols of unreacted ammonia will be available for recycle. Therefore, the make-up feed ammonia must equal 10—1.6 = 8.4 mols. The ratio of feed to recycle is 8.4/1.6 = 5.25.

The ultimate yield is generally computed as the amount of product divided by the amount of product theoretically formed on the basis of 100 percent reaction of the reactor feed exclusive of the recycle.

Theoretical product	= 8.4/2 = 4.2 mols
Actual product	= 3.5 mols
Ultimate yield	= 3.5/4.2 = 83.3 percent

Conversion is generally computed as the product in the reactor outlet divided by the amount of product theoretically formed on the basis of 100 percent reaction of the reactor feed including the recycle.

Theoretical product	= 10.0/2 = 5.0 mols
Actual product	= 3.5 mols
Conversion per pass	= 3.5/5.0 = 70.0 percent

According to these definitions of ultimate yield and conversion, the ultimate yield must always fall between the conversion per pass and 100 percent. The greater the amount of side reactions involved, the closer the ultimate yield will approach the conversion figure. Ultimate yields are important since they affect the raw material costs directly. The penalty for obtaining high ultimate yields is generally a lower conversion per pass which reduces the production capacity of a given unit.

Cost Evaluation: What to Include

In the design of a new process several cost estimates are made. The initial estimates are only approximate and are made to determine whether additional development is justified. If the preliminary estimates show the process is economically attractive, additional estimates of increasing accurracy are prepared from more advanced designs based on the most recent experimental data. The objectives of the cost estimates are to estimate the capital investment required and the unit cost of manufacturing the product.

The unit cost consists of two distinct types of charges: fixed costs and operating costs. Fixed costs are independent of the amount of production and are proportional to the plant investment. Operating costs depend directly on the production and, with the exception of mainenance, are not related to the plant investment. For example, depreciation of plant equipment and buildings

TABLE 1

Fixed Cost	Operating Cost
Depreciation or Amortization	Raw Materials
Interest	Utilities
	Fuel
	Steam
Taxes	Electricity
	Water
Maintenance and Overhead	Sanitation
	Waste Disposal
	Labor
	Maintenance

continues regardless of the plant production. In contrast, raw material costs depend directly on the amount of product produced. Table 1 lists the various costs under the proper classification.

Depreciation or Amortization. The capital required for building a new unit or plant may be obtained from company funds or borrowed from investors. In either case, the money is amortized over a period of several years. The length of time may be influenced by any or all of the following factors:

1. Useful life of the equipment

2. Allowable depreciation rate for income tax purposes

3. Useful life of the process

4. Company's payout policy

In Method 1, the depreciation per year is computed on the basis of the estimated life of the equipment. Since equipment life varies, an average for a given unit is used in most cases. Method 2 involves the use of depreciation rates published by the Bureau of Internal Revenue in Bulletin F on "Depreciation and Obsolescence Rates." This permits computing the actual unit cost based on the proper income tax procedure. If the selling price is known, the actual profit before taxes may be determined. Esentially, Methods 1 and 2 are identical since both are based on the estimated useful life. Differences do exist since the estimates are made under different circumstances by different groups. The government estimate represents an average for many companies. Thus, a company should be in a position to make a closer estimate of the actual life if they so desire.

A process may become out-of-date, as does an automobile; and, although the equipment is still in good condition, the unit may be abandoned before the equipment has become obsolete. In some industries, processes change so rapidly that they are not economical in a few years—sometimes, less than three years—The petroleum industry is well known for out-dating its present processes in a few years. If the development in a field is rapid, Method 3 should be considered. There is not much point to evaluating the process on the basis of a twenty year depreciation when it is known a five year life may be more realistic. In this same category, are processes where the raw materials are not inexhaustible. Mining operations, gasoline plants and oil refineries are examples. The life of a natural gasoline plant is quite often determined by the life of the gas production. In this case, the more realistic economic evaluation would consider the depreciation based on the life expectancy of the gas field.

Some companies evaluate new processes on the basis of less than a five-year depreciation rate since they feel new investments should consider only the more promising returns. This procedure has been labeled Method 4.

Instead of assigning a definite depreciation rate, the profit may be computed by determining the number of years required to pay out the plant investment. Both the profit excluding and including depreciation should be considered in this type of evaluation. Additional discussion of this procedure is presented later.

To illustrate the four methods of computing the depreciation, consider an ethylene unit with a plant investment of $1,500,000.00.

Method I If the useful life of the equipment is 10 years, the depreciation would be $150,000 per year

Method II Bulletin F suggests an average life of 15 years. Therefore, the depreciation would be $100,000 per year

Method III The increasing cost of the feed stock will make the unit uneconomical in 5 years. This would result in a value of $300,000 per year for depreciation

Method IV To attract capital, a 3-year depreciation is necessary. Depreciation would then be $500,000 per year

This example illustrates the large variation, $100,000 to $500,000 which is possible depending upon the viewpoint of the process engineer. It would be difficult to say any of the methods is more accurate than the others. Each has its own particular advantage.

The methods given are all based on a straight line or uniform depreciation rate. More complicated depreciation rates are possible and possess certain advantages. It is possible to increase the depreciation rate in the initial years to a limited extent. Current income tax laws should be consulted for a discussion of the proper procedure. Such a procedure is advantageous since it reduces corporate income taxes and would allow faster growth.

Interest. Regardless of whether the capital investment is to be obtained from company funds or made available by bankers, it is logical that the invested capital earn a fair interest. If the company funds are not used for the new unit, then they could be invested to bear a reasonable interest. If the capital is raised by issuing bonds or by borrowing from another corporation, interest would be paid the investor. It should be pointed out that in order to offer a company the incentive to invest its money in a new plant, it should be able to realize as large an interest rate as it could earn by making other investments. Since the risk is somewhat higher than certain conservative investments, the interest rate should be higher than that offered by these securities. Excessive interest rates are not realistic in view of today's regulatory laws. Normally, an interest rate of from 6 to 8 percent on the unpaid principal is considered satisfactory.

In computing interest, it is necessary to remember that the amount of interest will decrease each year since the unpaid balance is reduced by the depreciation allowed the previous year. An interest rate of six percent would average approximately 3.6 percent of the total principal each year if the principal is repaid in ten installments. It is customary to express the interest as a uniform fixed cost item each year.

In reality, the interest will decline each year and, therefore, the payment on the principal will increase if uniform principal plus interest payments are made. Uniform payments for n periods required to pay the original sum P can be computed from the equation

$$R = P\frac{i\,(1+i)^n}{(1+i)^n - 1}$$

P = original sum
R = uniform periodic payment
n = number of payments
i = interest rate as fraction per period

Continued on next page

The expression $(1-i)^n$ is the compound interest expression found in table form in many handbooks (Lange, *Handbook of Chemistry*). Table 2 lists values of $i(1+i)^n/(1+i)^n-1$ for various values of n and i.

TABLE 2

Values of $\frac{i(1+i)^n}{(1+i)^n-1}$

n	2%	3%	4%	5%	6%	7%	8%	9%	10%
1	1.020	1.030	1.040	1.050	1.060	1.070	1.080	1.090	1.100
2	0.515	0.523	0.530	0.538	0.546	0.554	0.561	0.569	0.576
3	0.347	0.353	0.360	0.367	0.374	0.381	0.388	0.395	0.402
4	0.263	0.269	0.275	0.282	0.289	0.295	0.302	0.309	0.315
5	0.212	0.218	0.225	0.231	0.237	0.244	0.250	0.257	0.264
6	0.179	0.185	0.191	0.197	0.203	0.210	0.216	0.223	0.230
7	0.155	0.161	0.167	0.173	0.179	0.186	0.192	0.199	0.205
8	0.137	0.142	0.149	0.155	0.161	0.167	0.174	0.181	0.187
9	0.122	0.128	0.134	0.141	0.147	0.153	0.160	0.167	0.174
10	0.111	0.117	0.123	0.130	0.136	0.142	0.149	0.156	0.163
12	0.0864	0.100	0.107	0.113	0.119	0.126	0.133	0.140	0.147
14	0.0826	0.0885	0.0947	0.101	0.108	0.114	0.121	0.128	0.136
16	0.0736	0.0796	0.0858	0.0923	0.0990	0.106	0.113	0.120	0.128
18	0.0667	0.0727	0.0790	0.0855	0.0924	0.0994	0.107	0.114	0.122
20	0.0612	0.0672	0.0735	0.0802	0.0872	0.0944	0.102	0.110	0.117

If the original investment was $1,500,000 and the loan was at 6 percent interest for ten years, the uniform payment would be

$$R = (1{,}500{,}000)\ \frac{.06\ (1+.06)^{10}}{(1+.06)^{10}-1}$$

$$R = 203{,}808.80$$

In ten years the total payment would be $2,038,088.00. Thus, the total interest is $538,088.00 and the average interest rate would be

$$\frac{538{,}088.00}{10\ (1{,}500{,}000)} = 3.59 \text{ percent}$$

Taxes and Insurance. Since the tax structures vary widely with locality, it is difficult to generalize tax rates. However, with the exception of corporation income taxes, they seldom exceed a total of 3 percent of the plant investment. Taxes are levied by federal, state, county and city governments. The more common types are: Real Estate, Property, and Excise or Privilege. In order to determine the exact amount of taxes, it would be necessary to be familiar with existing tax laws in the particular locality involved.

Insurance rates are also difficult to determine unless specific rates are investigated for a particular locality and business. Insurance normally falls into the three general classifications: Fire and Extended Coverage, Comprehensive Liability, and Workmen's Compensation. Rates for the latter two are based on the payroll and therefore are more of an operating cost than a fixed cost. A discussion of these two classifications will be made under a section on labor costs. Fire and Extended Coverage may be estimated at 2 percent of the plant investment.

Unless specific knowledge of tax and insurance rates are to the contrary, an estimate of 5 percent of the total investment should be reasonable in many cases.

Maintenance and Overhead. A certain amount of maintenance is required by equipment and buildings, independent of the amount of plant production. For this reason, it seems logical to treat at least part of the maintenance as a fixed cost. Unless prior experience with similar units indicates otherwise, a figure of 3 to 5 percent of the plant investment is used for maintenance.

Overhead includes such items as administrative salaries, office supplies, clerical salaries, engineering, research and sales. Together, these items may vary from 2 to 10 percent of the capital investment exclusive of sales overhead. Sales overhead may be computed on the basis of the selling price of the product.

Raw Materials. Raw material costs are an important part of the cost of the finished product in many industries. In petroleum refining, the crude oil is the major part of the cost of the product. If the ratio of raw material to finished product cost is high, it is desirable to acquire as accurate information as possible with regard to the raw material costs.

Current cost of chemicals may be found in the *Oil, Drug and Paint Reporter,* or *Chemical Engineering News Edition.* The cost of petroleum products is listed by the *Oil and Gas Journal* and the *National Petroleum News.* When determining the cost of raw materials, an allowance for transportation to the plant site should be made. Freight rates for various commodities can be obtained from railroads operating in the area in question. Railway rates vary greatly depending on the volume and competition from other forms of transportation. In particular barge and pipe lines offer the most competition and result in the lowest rates.

Dependability of raw material supply is another important consideration which should not be overlooked. The supply may depend upon reserves as in the case of natural gas or crude oil, or it may be a material whose supply may be limited by strike, storm or season. If the supply is not dependable, or is seasonal, it is wise to provide adequate raw material storage at the plant. This will increase the capital requirements for storage facilities and raw material inventory, but it is desirable in certain cases. An example is an alcohol plant using blackstrap molasses. The molasses is a seasonal import and storage facilities represent a large part of the plant investment.

Utilities. The utilities supply the heat and work energies for a process. In some processes, the utilities represent an appreciable portion of the cost of the product. For example, consider the production of ethylene from propane. This reaction carried out at temperatures in the range of 1500 F. requires substantial quantities of heat. Schutt[4] reports that the utilities represent 16 percent of the cost of producing ethylene. In general, utilities include fuel, steam, electricity, water, sanitation and waste disposal. An appreciation of the respective cost on an energy basis is helpful to the process engineer. If a cost comparison of various forms of energies is made on an equivalent heat basis, the corresponding costs are

Electricity	1 mill/kw-hr
Steam	28.4 cents/1000 lbs
Natural Gas	25.5 cents/1000 std cu ft
No. 6 Fuel Oil	$1.76/bbl
Bituminous Coal	$7.65/ton

This comparison does not consider furnace efficiencies of the gas, oil or coal. Since electricity or steam can be utilized at nearly 100 percent efficiency in heating operations, a more realistic comparison would decrease

the cost of the gas, oil or coal from 20 percent to 40 percent, depending on the furnace efficiency.

Steam, electricity and gas are commonly used to supply work energy. Selection of the most desirable form of energy depends upon several factors, the most important being cost and availability. Steam can be converted to work energy in a steam turbine at efficiencies as high as 30 percent. Electricity will provide work energy in electric motors with efficiencies of 90 percent. Gas is best converted to work energy in an internal combustion engine where efficiencies of 26 percent are possible. Using the above conversion efficiencies, the equivalent cost of the three methods of supplying work energy are:

Electricity	1 mill/kw hr
Steam	8.5 cents/1000 lbs
Gas	7.5 cents/1000 cu ft

To illustrate, consider the selection of the most economical drive for a gas compressor of 1000 horsepower. Assume electricity costs 7 mills per kilowatt hour and natural gas is available at 20 cents per 1000 cubic feet.
Solution:

Electricity consumed $= 1000(0.746)/0.90 = 829$ kw
Cost at 7 mills $= 0.007(829) = \$5.80$/hr
Gas driven compressors are available which require 10 cu ft of natural gas (1000 Btu) per hr per horsepower
Gas required $= 10{,}000$ cu ft per hr
Cost at 20 cents $= \$2.00$ per hr

Thus, energy costs for a gas-driven compressor can be far less than for an electric drive.

The comparison above involves the same type of energy; namely, all heat or all work. Sometimes it is possible to substitute one form of energy for the other at an appreciable savings. An outstanding example is the heat pump principle used to heat buildings. The same principle can be used in process studies—for example, in distillation units. Another illustration is the use of work energy to evaporate water in vapor-compression distillation systems.

To emphasize the savings in energy utilizing the heat pump principle, consider the following problem:

Assume that the heat loss from a residence is 100,000 Btu/hr when maintaining the inside at 70 F. with the outside atmospheric temperature at 0 F. If the heat pump utilizes well water at 55 F., compare the electrical energy requirements with direct electrical heating.

$$\text{Ideal Heat Pump } w = \frac{q_1(T_1 - T_2)}{T_1} \qquad \text{(See Dodge[5])}$$

$$w = \frac{100{,}000}{3413} \cdot \frac{(515 - 460)}{515}$$

$$= 3.1 \text{ KW}$$

Since this computation assumes an ideal working fluid, actual requirements using freon would increase the electrical requirements to perhaps 5.0 kw Direct Electrical heating $= \frac{100{,}000}{3413} = 29.3$ kw. Thus, if electrical power were available at 1 cent per kw-hr, the heat pump system would cost 5.0 cents/hr and the direct electrical heating system would be 29 cents/hr. Such a comparison emphasizes the importance of proper selection of the method of furnishing energy to a system.

Previous experience is a great help in decisions on alternate equipment. Yet, it can be a handicap since there is a tendency to rely on previous designs where conditions may not be identical. The safest approach is to perform the comparison calculations.

Fuel. This classification includes coal, oil and gas. The choice of fuel for the most part is made on the basis of cost, and this in turn is affected, to a large extent, by location. In recent years, pipe lines are bringing about changes in the accessibility of oil and gas. Transportation of coal by pipe line is being studied seriously by the coal industry. It is not always possible to use one fuel, since a plant shutdown from a fuel shortage is very costly. Industrial gas contracts are generally written on the basis of an interruptable service. These factors force many companies to provide standby fuels. Oil or LPG systems are favored for this purpose.

Natural gas is preferred over oil and coal if the price is competitive. The Southwest is fortunate in having such large reserves of natural gas. In 1940, field price of gas was as low as 1 cent per 1000 cubic feet. Now, contracts are written for prices of 10 to 20 cents per thousand cubic feet at the wellhead. If the plant is far removed from gas fields, the cost of transmission can add considerable cost.

The average wellhead price for natural gas was 7.3 cents per thousand cubic feet in 1951. Average industrial price at point of consumption was 14.6 cents in the same year. The average industrial price for several states in 1951 was:

State	Average Industrial Price (Cents per 1000 cubic feet)
Arkansas	9.4
California	21.3
Illinois	25.8
Kansas	13.3
Missouri	16.0
Michigan	51.6
Ohio	40.3
Oklahoma	8.2

Present industrial price in the Southwest is near 20 cents per 1000 cubic feet.

Average cost of bituminous coal at the mines in 1951 was $4.92. Anthracite averaged $9.51. A No. 6 fuel oil at Oklahoma refineries sold for $1.80 per barrel in 1951. For comparison purposes, the price of various fuels must be computed at the same Btu basis. The following average net heating values may be used:

Bituminous Coal	13,050 Btu/lb
Anthracite Coal	12,700 Btu/lb
Petroleum Coke	15,000 Btu/lb
No. 6 fuel oil	17,200 Btu/lb
Natural Gas	870 Btu/std cu ft
Propane	2,388 Btu/std cu ft

These heating values are the net values assuming the heat of vaporization of water formed on combustion is not recoverable. This is the more logical basis for comparison since combustion processes fail to condense the water formed during combustion. If the price of natural gas is taken as 20 cents per 100 cubic feet, the following prices of the other fuels would be equivalent on a Btu basis:

No. 6 fuel oil	$1.38/bbl
Propane	2.0¢/gal
Petroleum Coke	6.90/ton
Anthracite Coal	5.83/ton
Bituminous Coal	6.00/ton

The above costs assume that the combustion equipment will have the same efficiency regardless of the type of fuel.

Steam. Steam costs depend largely upon the cost of the fuel. Boilers generally have a useful life of 15 years, so that the fixed charges are not great. If natural gas at 20

cents per 1000 cubic feet were used in a boiler of 85 percent efficiency, this fuel would contribute 33 cents toward the cost of 1000 pounds of steam. Actual steam costs can vary from 20 to 75 cents per 1000 pounds. If the fuel costs are 20 cents per million British thermal units, a steam cost of 40 cents per 1000 pounds would be a fair estimate. For other fuel prices, steam costs may be varied accordingly. Most companies maintain accounting procedures which separate the cost of operating the steam generating plant from other units. This permits assigning a direct cost to steam when considering the addition of a new unit.

The effect of steam pressure on the cost can be neglected below 250 pounds per square inch gage. Steam at 600 psig can be estimated at a 10 percent greater cost than low pressure steam. The use of steam without returning the condensate imposes an additional load on the treating unit for the boiler feed-water. This additional cost for the process use of steam is the extra water treating cost. For most installations it would not exceed 2 cents per 1000 pounds.

It may be necessary to provide new steam generating facilities for a new plant. In this case, the steam boiler and accessories may be considered a part of the total plant investment. If desired, the operating cost for the steam boilers may be combined with the operating cost of the unit.

Electricity. Electric power may be purchased from a public utility or produced in the plant by use of steam turbines or gas engines. Most industrial power will fall in the range of 0.2 to 2.0 cents per kw-hr. A rate of 1.0 cent per kw-hr is a fair average.

In the generation of power from steam at 40 cents per 1000 pounds, the cost of the steam will contribute 4 mills/kw-hr to the cost of electricity. Using gas at 20 cents per 1000 cubic feet to furnish power for gas engine driven generators results in a 3 mill per kw-hr charge for the energy. Considering capital investment, maintenance and labor should not exceed 5 mills in each case. Therefore, both methods should produce electricity below 1 cent/kw-hr.

One of the least expensive methods of furnishing electric power utilizes the use of high pressure steam before subsequent use of process steam. In 1946 this procedure enabled one company to sell excess power at 1 mill per kw-hr. When steam passes through turbines and the exhaust steam is used in the plant, a procedure for prorating the cost must be established. An accepted method is to prorate the cost on the basic of the decrease in availability in each step. Dodge[5] presented a discussion of these calculations.

Water. The principal use of water is to provide cooling. If appreciable quantities are required, recirculation of the water through a cooling tower is necessary. Water from a cooling tower may be estimated at 1 to 2 cents per 1000 gallons. Water from wells or municipalities will cost from 10 to 30 cents per 1000 gallons. Only in recent years has the problem of water supply received much attention. Numerous cities are faced with a rapidly increasing consumption and diminishing sources of water. The government has appropriated research funds for development of economical methods of reducing the salt content of saline waters. One of the most pressing problems facing industrial expansion is a satisfactory water supply. The process engineer can reduce the water consumption of most processes by using air fin coolers whenever possible. It is important that the future plant expansion is considered from the standpoint of water consumption. Many cities are already considering the sources of water available for anticipated expansion twenty years from now.

Sanitation. In certain localities a charge is made for sanitation services. More often these services are paid by taxes or are associated with water rates. Investigation should be made to see what facilities are available. If these appear inadequate, an additionl plant investment will be necessary.

Waste Disposal. Industry is much more concerned over waste disposal now than ten years ago. Regulatory laws on waste disposal are being enacted and enforced which makes it desirable to design new installations with minimum waste disposal problems.

Millions of dollars are being spent by industry, state and local governments to develop more effective methods of reducing stream and air pollution. The best example is the effort to determine the reason for the smog in the Los Angeles basin.

Since waste disposal problems vary considerably, it is impossible to estimate the cost without knowing the type of unit and location. The literature[6] should be consulted when the design is started to see how others have handled this problem.

Labor. The average hourly wages for production workers in 1953 were:

Industrial organic chemicals	$1.97
Petroleum refining	2.32
Petroleum and natural gas production	2.21

To estimate the labor costs correctly, allowances for social security, vacations, insurance and workmen's compensation and shift-breaking must be made. These allowances may be computed on a percentage basis as follows:

	Percent
Social Security	3
Vacations	4
Insurance and Workmen's Compensation	2.5

Shift-breaking can be taken into account by providing enough production workers for three-shift operation without interference with the 40-hour week. This means using approximately one man for shift-breaking for every three men.

The total labor cost can be obtained by adding the supervision personnel needed to the operating labor. Since the hourly rates given represent average values, it may be desirable to obtain information on current local rates from the Bureau of Labor Statistics, Washington 25, D. C. An estimate of the direct operating labor for various chemical units has been correlated with production by Chilton.[7] In preliminary estimates such correlations are useful.

Maintenance. Annual maintenance costs have been discussed previously under fixed costs. In addition, maintenance allowances may be made on the basis of operating costs. Averaged maintenance costs for numerous types of equipment have been assembled by Leonard.[8]

Preventive maintenance is generally related to operating costs. The most satisfactory estimate of maintenance can be obtained from company records on similar operations.[9] To be effective, these records should be as complete as possible. A good example of maintenance prevention is reported by Buell & Weber[10] in connection with production of ethylene.

Profit. In order to evaluate the financial success of a process, it is necessary to determine the expected return on the investment. In order to judge the return properly, it is necessary to make a complete economic balance taking into account corporate income taxes. In considering the return on the investment, it is customary to consider the risk involved. A ten per cent return may be satisfactory in the case of established processes and favorable market prospects. A high return is desirable for ventures of greater risks. Some companies consider a twenty to thirty percent return necessary. Another way of estimating the success of a project is to determine the payout period required for return of the investment. *Business Week,* Jan. 22, 1949, presents a list of payout periods required by a number of companies. A majority of the petroleum companies required a payout of five years or less. In the manufacture of petrochemicals, most companies require a payout of less than three years. However, in each industry, economic analysis becomes quite involved.[11,12,13]

In order to determine the profit or payout, it is necessary to determine the total manufacturing cost or unit cost. The unit cost is the sum of the fixed and operating costs for a given calendar period divided by the quantity of production for that period. Since fixed costs are based on a calendar day, and operating costs on an operating day, it is important that each are calculated on the correct basis when obtaining the unit cost.

The profit is determined as the difference between the income from the product and any byproducts minus the sales expenses minus the unit cost. This represents the net income to which state and federal income taxes apply. The current rate for federal corporate income taxes is fifty percent. Although state income taxes vary, an average of three percent will be satisfactory for most estimates. After subtracting the income taxes, the net profit can be calculated and the return on the investment obtained by dividing the net profit by the capital investment. If desired, the payout period can be computed by dividing the capital investment by the net annual profit.

The effect of taxes has been discussed by Chiswell and Merrill.[14] By way of specific example, a comparison of two processes is made involving the manufacture of ethylene oxide. One process employs a direct oxidation; the other uses the chlorohydrin route. The capital investment required for direct oxidation was $6 million and for the chlorohydrin, it was $3 million. Excluding income taxes and amortization, the cost was 9.9 cents per pound of product for the oxidation route against 14.4 cents per pound for the chlorohydrin route. Taking into consideration income taxes and a four year amortization, the total costs become 17.9 cents per pound and 18.4 cents per pound. This strongly emphasizes the effect of income tax on processes requiring different capital investment. Without considering income tax, management would be inclined to consider direct oxidation on the basis of actual cost. However, it is doubtful if the direct oxidation would be considered in such favorable light in view of income taxes when considering the much higher investment required. Corporate income taxes are discussed by Chiswell and Merrill[14] as an important factor in comparing units of different capacities.

Plant Investment: How to Estimate It

It is difficult to compare the plant investment of plants where specifications are limited. Therefore, it is advantageous in comparing alternate processes to have cost estimates prepared by the same individual or department so that results are on a comparable basis. This is probably the most significant reason for making your own preliminary cost estimates. A recent illustration is the various discussions of processes for treating saline water for industrial use. To make a fair comparison and place plant investments on a common basis, it would be desirable for one engineering organization or individual to make a cost analysis of the proposed methods.

The plant investment can be affected appreciably by intangible factors, depending upon the shortages of material and labor, the scarcity of bidders, the necessity of maintaining a completion schedule. These factors are difficult to evaluate. For example, premium time would result if a 48-hour work week were employed to meet construction schedules. The labor payroll would be 16 percent higher if double time were paid for time over 40 hours. Still another factor would be that labor on a 48-hour basis may not be as productive as on 40 hours.

A simple correlation of plant investment with plant capacity is helpful in determining the total investment for a given capacity if the investment is known for one size plant. Chilton[15] shows that slope of the investment versus capacity curve is substantially 0.6 for 36 different types of plants. This indicates the ratio of plant investments is equal to the 0.6 power of the ratio of plant capacities. If the size of the plant is doubled, then the investment is increased by a factor of $2^{0.6}$ or 1.52. A word of caution is advisable in using this rule for other than preliminary estimates and for large extrapolations between plant sizes.

Plant investment may be broken down into the following items:

- Plant Site
- Surveys and Preliminary Reports
- Process Equipment
- Installation Costs
- Process Piping
- Electrical
- Instrumentation
- Insulation and Painting
- Service Facilities
- Buildings
- Contingencies
- Engineering and Contractor Fees

Each of these items will be discussed in some detail. If all the items making up the total investment are fully dis-

cussed, better application of the shorter methods should be possible. An illustrative problem involving estimating the plant investment by two or more methods will be presented following the discussion of the above items.

A process engineer is continually faced with the problem of maintaining his files of cost information adjusted to a current basis. Unless such a current file is available, it is necessary to develop a method of adjusting published cost data to current dates. Before discussing the cost of various items comprising the plant investment, a discussion of a method for adjusting cost data to the same date seems appropriate.

Cost Indexes. It has been customary for estimators to use cost indexes to adjust construction cost to the different dates. Several indexes on construction and building costs are available. Three commonly used by process engineers are: *Engineering New Records—Construction Cost Index, Stevens and Marshall Equipment Cost Index,* and *Nelson Refinery Construction Cost Index.*

A discussion of the *Stevens and Marshall Equipment Cost Index* is presented by Stevens.[16] This index lists equipment costs for various processes and related industries from 1913 to date. A hypothetical distribution of equipment, piping, labor and overhead is assigned to each industry. For the oil industry, the index contains the following components: process machinery 25 percent, tankage 24 percent, pipe and fittings 12 percent, installation labor 19 percent, power 12 percent, maintenance equipment 2 percent, and administration 6 percent.

A convenient index used by many process engineers is the construction cost index published monthly by *Engineering News Record.* This ENR index is based upon a hypothetical block of construction requiring 6 barrels of cement, 1.088M feet BM of lumber, 2500 pounds of steel and 200 hrs of common labor. A value of 100 has been assigned the value of the index in 1913. Monthly values are published in the *Engineering News Record.* Each year an annual issue presents a supplement summarizing the history of the index and discusses its value in 21 cities during the last five years. The last supplement was published Oct. 7, 1956. Table 3 lists the average value of the ENR construction cost for the years 1926 to date on the basis of 100 for the year 1913.

By using the ratio of the cost index for any two years, it is possible to convert construction cost from one year to another. For example, in 1940 the index was 241.96. The value in January, 1957, was 705. Therefore, the cost of construction in 1957 would be 2.91 times the cost of construction in 1940. It should be stressed that these indexes do not allow for intangible factors, such as overtime, shortage of labor and material, and lack of competition among contractors. These intangibles may increase the cost from five to twenty-five percent depending upon conditions.

The Nelson Refinery Construction Index is explained in *Oil & Gas Journal, 54,* 110, Oct. 1, (1956). The index is published in the first issue each month. Indexes of individual equipment items are listed quarterly. Applying the individual equipment index to a particular item should result in a more accurate estimate. However, for complete plant cost, the over-all indexes are probably as accurate and are much easier to use.

Plant Site. The location of the plant site will greatly affect the cost of the land. In rural locations, the cost may be as low as $100 an acre. Undeveloped land adjacent to industrial districts may range in price from $350 to $1000 an acre. Locations in industrial districts in which utilities, streets, fire protection are available range from $1000 to $8000 an acre.

In addition to the land cost, plant site improvements are required.

TABLE 3
ENR Construction Cost
(Basis 1913 = 100)

YEAR	Index	YEAR	Index
1926	208.0	1942	276.3
1927	206.2	1943	290.0
1928	206.8	1944	298.7
1929	207.0	1945	307.8
1930	202.9	1946	346.0
1931	181.4	1947	413.2
1932	157.0	1948	460.7
1933	170.2	1949	477.0
1934	198.1	1950	509.4
1935	196.4	1951	542.7
1936	196.4	1952	569.4
1937	234.7	1953	600.0
1938	235.8	1954	628.0
1939	235.5	1955	659.7
1940	242.0	1956	692.4
1941	257.8		

These improvements include surveying, grading, railroad siding, roads, parking areas, fence and utilities. The preparation and grading of the plant sites is influenced by the terrain. Hilly areas can require costly grading operations.

Railroad sidings may be estimated at $10 per lineal foot. This makes allowance for grading, ballast, track and switch. Roads may be estimated from $12 to $25 a lineal foot for a 22 foot width with curb. In the Midwest, the lower cost is for asphalt or macadam construction and the higher cost for concrete. Parking areas with blacktop may be obtained for $4 a square yard. The chain link fence used frequently can be computed at the rate of $3 a foot if there are not an excessive number of gates.

Utilities include electricity, water, steam, gas and sewer connections to existing facilities. It is difficult to make any general statement as to their cost since the length of lines and the size of the mains greatly affects the cost. The policy of power companies varies with regard to supplying transformer equipment. Some utilities supply the transformer equipment, while others prefer to have the company pay for the cost of the equipment.

In considering new locations, it is extremely important to check into the utility facilities that are available so that an estimate may be made which will be realistic. If the plant sites are located in river beds, industrial water for cooling can be obtained from shallow water wells. For example, in the Kansas City area, near the Kansas or Missouri Rivers, water wells can be obtained at a depth of 70 to 150 feet which have capacities from 300 gallons to 1000 gallons per minute. A representative average cost for wells of this type including the well and pumping equipment is:

100 gpm	$1500
500 gpm	6000
1000 gpm	7500

Process Equipment. Regardless of the type of estimate prepared, it is customary to estimate the cost of the major process equipment. This process equipment includes all items classified as pressure vessels, reactors, heat exchangers, separators, fractionators, pumps, storage tanks, filters, dryers, etc. It is important to include any allowance for freight to the plant site so that the estimated cost is f.o.b. plant site. In the case of the pressure vessel and fractionating columns, the freight usually represents less than one percent of the cost of the equipment.

Pressure vessels, separators, fractionating columns and storage tanks can be estimated with fair accuracy without obtaining actual quotations. In general, the weight or volume is computed and the prices calculated on the basis of a unit price per weight or volume. Articles by Bliss,[17] Chilton,[18] Dickson,[19] Fowler & Brown,[20] Fox,[21] Happel et al,[22] How,[23] Nelson[24] present the cost of pressure vessels, storage tanks and separators. The cost of fractionating columns are discussed in detail by Chilton,[18] Fowler & Brown,[20] Happel et al,[22] and Nelson.[24] In general, they are computed on the same basis as pressure vessels with the additional cost of bubble trays. These articles were published from 1943 to 1953 and it should be remembered that adjustments for increases in costs of fabrication must be made in each case to bring the prices up-to-date.

In arriving at the weight of a pressure vessel, it is necessary to compute the wall thickness of the head and shell according to the ASME code for unfired pressure vessels. The specific formulae are:

Shell thickness

$$t = \frac{PD}{2sE - P} + c$$

Ellipsoidal Heads

$$t = \frac{PD_mV}{2sE} + c$$

where P = Allowable working pressure psig
D = Inside diameter in inches before corrosion allowance is added
D_m = Average of inside and outside diameters
s = Maximum allowable working stress corresponding to operating temperature at temperatures below 650 F. computed as ¼ the ultimate strength in tension
E = Efficiency of welded joints
V = Factor depending on ratio of major to minor axis
c = Allowance for corrosion in inches

For most carbon steel vessels, the steel will confirm to specifications indicating an ultimate strength of 55,000 psi. Therefore, s = 55,000/4 = 13,750 psi when the operating temperatures are below 650 F.

The value of *E* varies, depending upon the type of weld and whether the joint is stress relieved or examined by X-ray. A normal double-welded butt joint has an efficiency of 80 percent. The value of *E* is increased by the factor 1.06 if stress relieved and by the factor 1.12 if X-ray inspected.

Ellipsoidal heads with a major to minor axis ratio of 2.0 are commonly used. The value of *V* is 1.0 for this ratio.

To determine the weight of the shell, it is helpful to remember that steel has a density of 490 pounds per cubic foot, or a steel plate ¼-inch thick and 1 square foot in area weighs 10.2 pounds.

The articles by Bliss,[17] Chilton,[18] Happel et al,[22] Kern,[27] Smith and Edison[26] and Zimmerman[25] report cost data on numerous types of process equipment including furnaces, compressors, liquid pumps, filters, dryers, kilns, autoclaves, evaporators, cyclone separators, gas holders, thickeners, heat exchangers,[27] crushing and grinding equipment, and electric motors.

It should be pointed out that Chilton's articles present the installed cost rather than the cost of the delivered equipment. Therefore, his costs cannot be compared with the others without making allowances for the cost of foundations, installation, labor, insulation and painting. Nelson[24] has published a series in recent years on "costimating" for the petroleum industry.

Installation Cost. An estimate of the installation costs for the major equipment must be made. The installation cost includes foundation, structural steel and the erection cost. Chilton[18] presents the cost of his equipment on the basis of installed cost and it is not necessary to add an allowance for installation. Happel et al[22] discusses the installation costs for various types of equipment as a percentage of the costs of the item.

Foundations may be estimated by determining the number of yards of concrete required and then multiplying this by a unit cost per yard. Depending upon the complexity of the foundation, a cost of $50 to $200 per cubic yard may be used. This includes the cost of excavation, forms, structural steel and concrete. Still another way is to lump the installation cost as a percentage of the equipment costs. Lang[28] indicates that the average installation costs represents 30 percent of the cost of installed equipment. 30 percent may be broken down to 13 percent for foundation and 17 percent for erection labor and construction equipment rentals.

Process Piping. Piping costs represent an appreciable part of the cost of petroleum and petrochemical plants. It may represent 60 percent of the equipment costs. Dickson[29] published a detailed method of estimating piping costs including insulation. For most preliminary designs, it is customary to estimate piping as a percentage of the plant costs. Chilton[18] breaks down the piping costs depending upon whether the plant is processing solids, solids and fluids, or fluids. He assigns the ranges in costs on the basis of the percentages of installed process equipment costs as follows:

Solids	7 to 10 percent
Solids and Fluids	10 to 30 percent
Fluids	30 to 60 percent

Lang[28] presents a similar method. In this article, the percentages are:

10 percent for solid processes
25 percent for solid-fluid processes
60 percent for fluid processes

The process piping excludes control valves and instruments. These items are normally associated with instrument costs. Service piping in buildings is included in the cost of buildings. Outside service lines are estimated separately or included in site improvement costs.

Buildings. Building costs, as a percentage of plant investment, show considerable variation with the type of process and its geographic location. For example, in an alcohol plant the process equipment is located inside buildings. Even storage tanks are located inside. In contrast, storage facilities for petroleum plants are always located outside and most of the process equipment is also placed outside. The climate also affects the amount and type of buildings. Southern locations permit more open construction and reduce building costs. Manufacturing buildings, in the case of an alcohol plant, may represent 100 percent of the total cost of the process equipment. Natural gasoline plants seldom require an investment of 5 percent of the process equipment in buildings.

Sheet metal buildings may cost as little as 30 cents per cubic foot, while brick and masonary construction may cost as much as $1.50 per cubic foot.

Electrical. The electrical installation generally is 5 percent of the total plant cost. Lang[28] presents a breakdown on 14 different plants ranging in size from $100,000 to $15,000,000. The electrical installation varied from 8 percent to 3 percent of the total plant costs. The smaller percentage applies to the larger plants. Happel et al[22] state the costs of electric equipment at 17 percent to 45 percent of the cost of the process equipment. Chilton[18] includes the cost of electrical equipment in the installed cost of the process equipment. Therefore, it is not necessary to make allowance for electrical equipment if Chilton's procedure of cost estimation is followed.

Instrumentation. In plants where instrumentation is held to a minimum, the cost could be estimated at not more than 1 percent of the total plant cost. Both the petroleum and petrochemical fields are liberal in their application of automatic controls. Therefore, instrumentation is an important part of the plant investment. Considine[30] discusses instrument costs and a method of estimating the installed costs including accessories. An average of 5 percent of the process equipment costs is representative of the installed instrument cost for the petroleum industry. Chilton[18] indicates costs as high as 10 percent to 15 percent of the process equipment costs.

Insulation and Painting. The cost of insulating and painting the equipment may be estimated on a square foot basis or as a percentage of the process equipment. The latter method is used by most process engineers in making preliminary estimates. In petroleum units the insulation and painting will range from 10 percent to 15 percent of the process equipment.

Service Facilities. Service facilities include all service piping within the plant site, such as steam for heating, water for drinking and sanitation purposes and gas for heating. Electrical service is combined with the process electrical requirements. On this basis the cost of service facilities will vary from 6 percent to 20 percent of the process equipment. Extension of utilities to the plant site properly belongs under improvement cost on plant sites.

Contingencies. An allowance for contingencies depends upon the effort expended in making the preliminary design and estimate. For careful design, it is seldom necessary to add more than 10 percent for contingencies. If the process is subject to various process alternatives and changes, it would be wise to add an additional 20 percent for contingencies. This percentage is generally applied to the total plant cost exclusive of the engineering and contractor's fee.

Engineering and Contractor's Fee. This item depends upon the competition between contractors and size of the plant unit. If the plant investment exceeds $1 million the engineering fee generally would be less than 15 percent, while in small units of $100,000 size, the engineering and contractor's fee may run as high as 20 percent to 30 percent. Lang[28] estimates engineering and construction at 31 percent to 38 percent of the cost of the plant. This includes contingencies, field office expenses, temporary construction, engineering expenses and the contractor's fee.

Simplified Cost Estimate. Simplified cost estimates can be made from only a knowledge of the plant capacity. This type is possible for certain units which have been constructed in the past. Since most units are rarely duplication in size, design and location, it is difficult to obtain exact estimates in this manner. However, if enough information on past construction is available, rather realistic estimates can be made by extrapolation of previous data. Perhaps refinery units offer the best possibility of employing this type of simplified estimate.[31, 32, 33] Tucker[34] and Nelson[35] list plant cost for various refinery units versus the plant capacity.

In another method by Lang,[36] restriction to units previously constructed has been avoided. The only information necessary is a total estimate of the delivered major process equipment. A multiplication factor is then applied which gives the total plant cost. This factor depends on the type of processing performed in the plant. The various classifications with the corresponding factors are:

Classification	Factor
Solid processing	3.10
Solid-fluid processing	3.63
Fluid processing	4.74

Hill[37] presents a similar short-cut for petrochemical plants.

Application of Estimating Procedures. To illustrate the use of previously discussed estimating procedures, an actual estimate of the plant cost of the propylene-butylene recovery unit shown in Figure 6 will be made by two different procedures:

Preliminary Estimate

Deethanizer—150 psia or 135 psig
Upper section—25 plates
Lower section—10 plates
Shell upper section

$$t = \frac{(135)(36)}{(2)(13{,}750)(0.80)} = 0.22''$$

Use ¼" thickness
Weight = (10.2)(25)(2)(π)(3) = 4800 lbs

Head upper section

$$t = \frac{(135)(36.1)(1.0)}{(2)(13{,}750)(0.80)} = 0.22''$$

Use ¼" thickness
Area of ellipsoidal head is approximately 1.38 times area of column

$$\text{Weight of head} = \frac{(10.2)(\pi)(3^2)(1.38)}{4} = 99 \text{ lbs}$$

Shell lower section

$$t = \frac{(135)(48)}{(2)(13{,}750)(0.80)} = 0.29''$$

Use 5/16" thickness

$$\text{Weight} = (10.2)\frac{(5)}{4}[10(2) + 5]\,\pi(4) = 4000 \text{ lbs}$$

Head lower section

Use 5/16" thickness

$$\text{Weight of head} = \frac{(10.2)(5/4)(\pi)(4)^2(1.38)}{4} = 220 \text{ lbs}$$

Total weight = 4800 + 99 + 4000 + 220 = 9120 lbs

From Happel's[1] article, cost data in 1946 were

Cost of shell and head @ 20 cents/lb
= 0.20 (9120) = $1824

Bubble trays were listed as $15 per sq ft in 1946

$$\text{Upper Section} = (25)(\pi)\frac{(3)^2}{4}(15) = 2660$$

$$\text{Lower Section} = (10)(\pi)\frac{(4)^2}{4}(15) = 1890$$

Total cost in 1946 of Deethanizer
= 1824 + 2660 + 1890 = $6374

The 1956 ENR index was 692.4 and the 1946 value was 346.0. Adjustment of the column cost to 1956 would give

$$\frac{(692.4)(6374)}{346} = \$12{,}750$$

Debutanizer—120 psia or 105 psig

$$\text{Shell} = \frac{(105)(54)}{(2)(13{,}750)(0.80)} = 0.26''$$

Use a thickness of 5/16" for shell and heads

$$\text{Weight of Shell} = (10.2)(5/4)[35(2) + 5]\pi(4.5) = 13{,}500 \text{ lbs}$$

$$\text{Weight of Heads} = \frac{(10.2)(5/4)(\pi)(4.5)^2(1.38)(2)}{4} = 560 \text{ lbs}$$

Total weight = 13500 + 560 = 14,060 pounds

Cost of shell and head @ 20 cents/lb
= 2.20 (14,060) = $2812

$$\text{Cost of trays} = (35)(\pi)\frac{(4.5)^2}{4}(15) = \$8340$$

Total cost in 1946 = $2812 + 8340 = $11,152

$$\text{Adjust cost to 1956} \frac{(692.4)(11{,}152)}{346} = \$22{,}304$$

Deethanizer Reboiler—550 sq ft

In 1946 Happel listed cost of heat exchanger
= (550)(4.50)(1.2) = $2970

Adjusted cost to 1956 = 2970(692.4/346) = $5940

Debutanizer Reboiler—1500 sq ft

In 1946 cost = (1500)(3.00)(1.2) = $5400
Adjusted cost to 1956 = 5400(692.4/346) = $10,800

Debutanizer Condenser—2500 sq ft

In 1946 cost = (2500)(2.50)(0.6) = $3750
Adjusted cost to 1956 = 3750(692.4/346) = $7500

Intercooler—400 sq ft

In 1946 cost = (400)(4.50)(1.0) = $1800
Adjusted cost to 1956 = 1800(692.4/346) = $3600

Cooler—1800 sq ft

In 1946 cost = 1800(3.00) = 5400
Adjusted cost to 1956 = 5400(692.4/346) = $10,800

Accum—since this vessel could be fabricated from 2' diameter pipe, the cost in 1956 is estimated at $ 300

Pumps—From Happel, the cost of pumps in 1946 were:

Debutanizer reflux pump—160 gpm—3 Hp	$400
Intercooler pump—68 gpm—2 Hp	$300
Deethanizer lean oil pump—35 gpm—2 Hp	$300
	$1000

Adjusted 1956 cost of all pumps
= 1000(692.4/346) = $2000

Total major equipment cost $75,994

Refer to preceding sections for discussion of various factors used in the following computations.

Installed Equipment Cost = 75,994/0.70		= $108,500
Piping Cost = 0.60(108,500)		= 65,200
Electrical = 0.25(108,500)		= 27,100
Paint and Insulation = 0.15(108,500)		= 16,300
Instrumentation = 0.10(108,500)		= 10,800
	Sub Total	$227,900
Contingencies = 0.10(227,900)		= 22,790
	Sub Total	$250,690
Engineering and Contractor's Fee = 0.25(250,690)		= 62,500
Total Plant Investment (excluding service lines, plant site and buildings)		$313,190

Simplified Cost Estimate. Using Lang's method, the plant investment is estimated as = 4.74(75,994) = $360,000

This indicates that fair agreement can be expected between the two methods. The accuracy of the preliminary estimate depends upon the judgment of the engineer in making allowance for various factors. Even inexperienced process engineers can make reasonable estimates using only the simplified methods.

Instrumentation: It Needs Attention

The information available to the process engineer with regard to the effect of variables on the performance of equipment can be most helpful in specifying the control systems. However, this knowledge is not always used to the best advantage. To help illustrate this point, consider the control of a distillation column. Many control systems have been proposed for distillation units and many are successful under certain conditions. However, predictions of the success of one method over another may be made without actual operation of both systems. Figure 8 shows two popular methods of column control. Both are identical with the exception of the overhead control. Method *A* employs a flow controller on the reflux and a pressure controller on the overhead stream. Method *B* uses a flow controller on the overhead stream, and a pressure controller on the reflux. Compare both methods when operating at a reflux ratio, L/D = 4.0 and when the overhead equals 30 percent of the feed. The following computation indicates the best system:

Assume that the vapor load decreases 10 percent due to a change in steam pressure or atmospheric conditions of wind or rain.

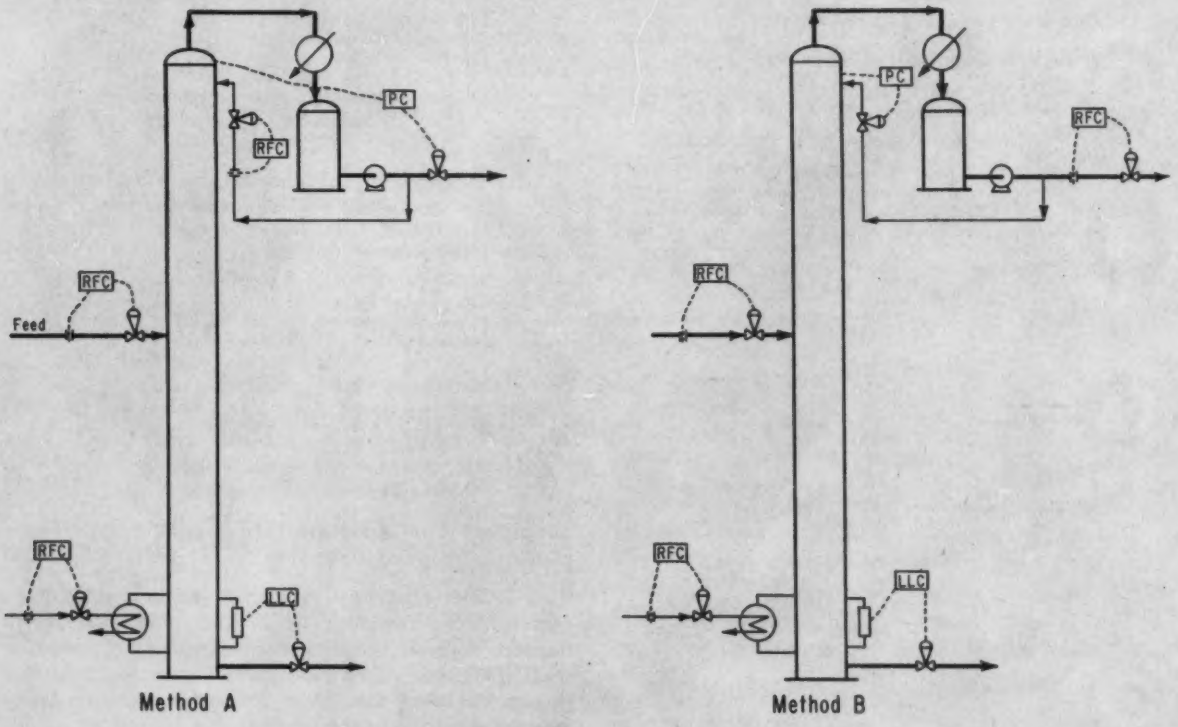
Basis	100 mols of feed	
Balanced conditions		
Overhead product	= 30 mols	
Bottom product	= 70 mols	
Reflux	= 4(30)	= 120 mols
Vapor load	= 120 + 30	= 150 mols
L/V	= 120/150	= 0.800
Decreased vapor load	= 150—15	= 135 mols
Method A		
Reflux	= 120 mols	
Overhead product	= 135—120	= 15 mols
Bottom product	= 100—15	= 85 mols
L/V	= 120/135	= 0.888
Method B		
Overhead product	= 30 mols	
Reflux	= 135—30	= 105 mols
Bottom product	= 70 mols	
L/V	= 105/135	= 0.778

Thus, Method *B* is the more satisfactory control since the L/V varies only 2.8 percent instead of 11 percent as for Method *A*. Method *B* also maintains the same split between overhead and bottoms regardless of the vapor load.

When more than one method of control is suggested, similar analysis will generally indicate advantages of one over the other. Unfortunately, instrumentation is not always specified from the process design standpoint.

It is hoped that the information presented will give those new to the field of process engineering an idea of the scope of the profession. At the same time, it is hoped that more engineers will make use of process-engineering and find it as interesting and challenging as those of us who are engaged in the field.

FIGURE 8—*These two methods for column control differ on overhead control. Method A uses a flow controller on the reflux and a pressure controller on the overhead stream; Method B uses a flow controller on the overhead stream and a pressure controller on the reflux.*



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INTRODUCTION TO SCALE-UP

CHANGING EQUIPMENT SIZE can give rise to very unexpected results. Here are some articles which show how the principle of similitude lets you better predict the results of scale-up.

The original text of these reports was presented before a symposium at the Church House, Westminster, London, May 28 and 29, 1957. The symposium was sponsored jointly by the following societies: Het Koninklijk Instituut Van Ingenieurs, De Koninklijke Nederlandse Chemische Vereniging, The Society of Chemical Industry, and The Institution of Chemical Engineers.

We present here condensations of some of these papers so that you can review the ones which most interest you. Here are the different subjects discussed:

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Consider the Economics Of Scale-Up

Scaling up usually does provide economies, but remember to consider these factors.

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WHEN PROBLEMS of scaling-up and size of plant are being considered, the engineer will find there are many decisions which must be made which cannot properly be decided solely on technical grounds. The question arises whether any economic advantage can be gained in scaling-up the size of individual units and the effect of such a course upon the economics of the plant as a whole. There may be a tendency for the practical engineering problems to take priority and the economic problems left to look after themselves unless certain principles are always borne in mind.

Application of the Principles. By his training, the engineer turns first to the determination of the form, dimensions, and materials of the constituent units of the plant to suit the needs of the process. At this stage the possibility of process obsolescence must be considered—it is wasteful to contemplate installing a plant which, by reason of the strength and nature of materials employed, will remain in operating condition for 25 years, if there is sound reason to believe that within say 5 years a more economic process will be developed.

Next, the engineer seeks technical efficiency which by experience leads him to the desirability of large units instead of small. This is conditioned by the need for reliability which may mean that a vital or key item, although within the size or capacity available from one large machine or unit, would be best as two or more units of reduced size so that breakdown of one will allow the plant to run although at reduced capacity.

Alternatively, it may be considered that the situation is best met by standby equipment at these crucial points. Load factor also has a considerable influence on the choice. If a large machine may be running at only a quarter of its normally rated capacity most of the time, and at normal rating only during its peak load, highest efficiency is best obtained by increasing the number of units.

If, on the other hand, at the time of installing the plant there is good prospect of expansion in the near future, the engineer will probably be justified in choosing most of the units in the first stage of construction so they are of the largest possible size and thereby economizing in first cost and obtaining higher efficiency eventually. In fact, in such circumstances it may be desirable, to install a plant larger than necessary to meet immediate requirements, in order to take maximum advantage of the "Economies of Increased Dimensions."[1]

There are many advantages to be gained by the use of manufacturers' standard equipment. This applies particularly to machinery when well-proven designs ensure reliability at reasonable first cost and ease in obtaining spares and replacements. What is often most important is that the equipment can be obtained quickly.

These values are suggested for the exponent "x" in the cost comparison equation. They were obtained by the author using prices in England for November, 1956.

Type	x
Steel Pipe (Standard Thickness)	0.77
Storage Tanks	
(Horiz, Cyl., mild steel)	
250-2,000 gal.	0.50
2,000-12,000 gal.	0.87
Avg.	0.69
Heat Exchanger (Air After-Coolers)	0.62
Pumps (Centrifugal)	0.25

Comparison of fixed Capital Costs in Relation to Size. To demonstrate the principle of decreasing capital cost per unit of output as capacity increases in single items of a plant, capital cost to the user may be plotted against a measure of output or capacity on a log-log grid. The slope of the line obtained by connecting the point plots, corresponds to the exponent "x" in the following comparison formula.

$$P_2 = P_1 (X_2/X_1)^x$$

Where

P_1 = price of the first "unit"
P_2 = price of the second "unit"
X_1 = capacity of the first "unit"
X_2 = capacity of the second "unit."

Much data have already been published showing correlations of cost to capacity.[2]

Scaling-Up Methods for Estimating Construction Costs. The question asked on some occasions is, "Is there a short-cut method which will give a reliable answer for a total plant without wading through a lot of detail?".

Chilton[3] believes there is, and analyses data published in the U. S. A. to conclude that the "Six-Tenths Rule" applies to complete plants. This means an exponent of 0.6 in the preceding comparison formula.

It is stated by Chilton that the average slope of the curves of all the plants considered including some where increase in output is obviously predominantly by multiple units, is 0.68 and the median is 0.66.

For the average plant of small-to-medium size, the conclusion reached by Chilton is in accord with the author's own experience. If increase in output is by "increased dimensions" then it is completely logical to accept and use an exponent of 0.6 when estimating another size of complete plant which is within this range. However, from experience it can be recommended that if time and basic information is not available when scaling-up the cost of a small commercial plant to one quite considerably larger, an exponent of about 0.72 can be used with confidence that it will provide relative costs with a fair degree of accuracy.

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How to Size Rotating Disc Contactors

Here are some formulae which reduce the amount of experimental data required to size commercial contactors.

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CORRELATING FORMULAE for the design of a rotating disc contactor have been developed to describe the influence of the structural factors on capacity and efficiency. Although these correlations exclude the properties of the liquid system, a few experiments in a laboratory contactor with the liquid system in question are all that is needed to complete the data required for sizing technical contactors.

A diagram of a rotating disc contactor is shown in Figure 1. It consists of a number of compartments formed in a vertical cylindrical shell by a series of stator rings. A flat rotating disc is centered in each compartment and supported by a rotating shaft. The energy transferred from the rotor discs to the liquid creates a fairly uniform turbulence.

Correlation of Capacity Data. Initial data obtained with standard test systems in contactors ranging in size from 2 inches to 8 inches indicated an increase in capacity from:

1. Decreasing rotor speed and decreasing diameter of the rotor discs.
2. Increasing diameter of the opening in the stator discs,
3. Increasing compartment height and
4. Decreasing ratio of the flow rates of the dispersed and continuous phases.

The approach which eventually led to a successful correlation of these data started from the fact that the drop size of the dispersed phase will play a preponderant role in determining the capacity. Hinze[1] has shown that in a turbulent field of flow the size of the drops in an emulsion is determined by the energy input per unit mass of the emulsion as well as by the physical properties of the liquid system.

The relation for the energy input per disc in the rotating disc contactor, P, is similar to the well-known formula for other impeller types:

$$P = \text{const.}\ \rho N^3 R^5$$

so that for the energy input per unit mass we obtain

$$\frac{P}{HD^2 \rho \cdot \pi/4} = \text{const.} \frac{N^3 R^5}{HD^2} \quad . \quad (1)$$

Thus for a given liquid system we may expect the quantity N^3R^5/HD^2 to be an important variable in determining the drop size of the dispersed phase, and consequently for correlating capacities of rotating disc contactors.

The settling of the drops is influenced by the flow pattern in the compartments and the restrictions of the contactor shell caused by stator and rotor discs. The easiest method to deal with these effects for correlation is to correct the observed capacities by dividing them by a factor equal to the ratio of the minimum cross-section and the free cross-section of the contactor shell. The success of this method of correlation for scaling-up can be judged from Figure 2.

The results given in these figures are valid for a constant ratio of the flow rates of the dispersed and continuous phases. At phase ratios higher than about three, where hold-up of the dispersed phase at flooding becomes larger than about 50%, the hold-up becomes so high that the concept of the normal hindered settling of the drops breaks down. Scaling-up of the capacity then becomes unreliable.

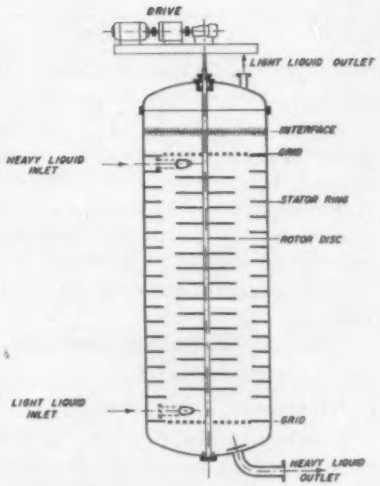

FIGURE 1—The drop size of the dispersed phase has the predominant influence on determining the capacity of a rotating disc contactor.

Correlation of Efficiency Data. Data obtained with standard test systems, in contactors ranging in size from 2 inches to 16 inches, indicate the following ways to increase efficiency, the latter being expressed in

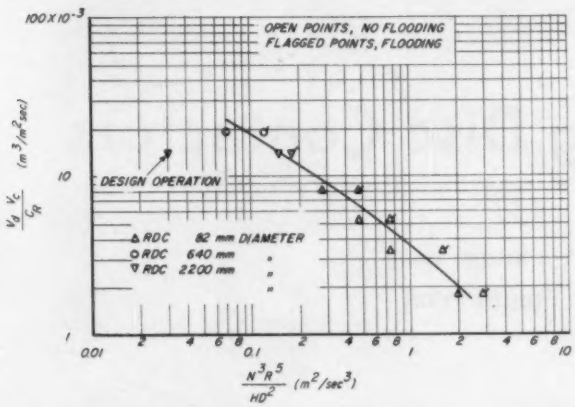

FIGURE 2—A 3:4 ratio of furfural to de-asphalted residue was used to obtain these flooding data. The furfural was the continuous phase.

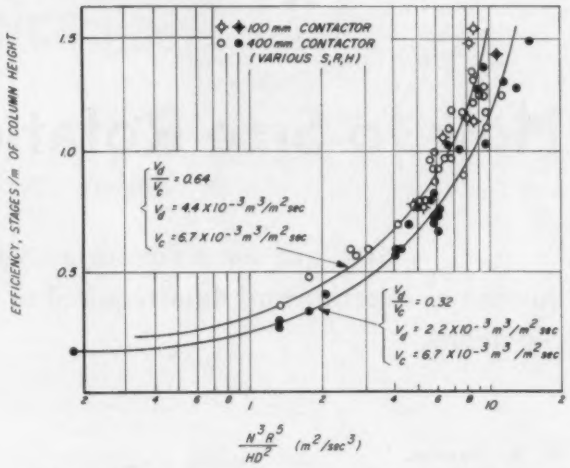

FIGURE 3—This shows how well the efficiency data may be correlated for a system of water, kerosine and butylamine. The water is the dispersed phase.

terms of stages per metre of contactor heights:

1. Increasing rotor speed. In certain cases, however, the efficiency passes through a maximum. This is caused by mixing phenomena throughout the extraction zone; it has also been orserved by Vermijs and Kramers.[2]

2. Increasing diameter of the rotor disc.

3. Decreasing diameter of the opening in the stator discs.

4. Increasing specific load.

5. Increasing the flow rate of the dispersed phase at constant flow rate of the continuous phase.

The above phenomena appear at first sight to be complicated but several of these points become clear, if the contactor is considered to be equivalent to a number of ideal mixers in series, through which the phases pass in counter-current flow. For such a system it can be shown (provided no entrainment of phases occurs) that the compartment efficiency η can be described accurately by the formula

$$\frac{\eta}{H} \cong \frac{6k}{d} \cdot \frac{h_D}{v_D} \cdot E^{0.5} \text{ for } \eta \leqslant 0.3 \quad . \quad (2)$$

The limitation of compartment efficiencies to about 0.3 or less is quite realistic. Although compartment efficiencies higher than this figure can easily be obtained by increasing H, this would in fact cause a loss in separating power, since the quantity η/H, i.e. the number of stages per metre of contactor height, starts to drop very rapidly for values of η greater than 0.3.

Equation (2) indicates that the quantity η/H, which is the inverse of H.E.T.S. will be suitable for correlation purposes. The drop size, d (and thus for given flow rates also the fractional hold-up of dispersed phase, h^D) will be determined by the energy input, i.e., N^3R^5/HD^2.

The mass transfer coefficient, k, may furthermore also be assumed to be determined by the energy input. Experiments on mass transfer in stirred vessels support this view.[3,4]

Hence it appears that η/H and N^3R^5/HD^2 are the main variables for the correlation of efficiency data, provided mixing throughout the extraction zone can be neglected. The success obtained in using these variables may be judged from Figure 3.

In general the scaling-up of efficiency can safely be done with the formula $\eta/H \cong D^{-0.15}$ for energy inputs lower than those given by $N^3R^5/HD^2 = 0.1$. For energy inputs of this magnitude, the effect of mixing on efficiency can in most cases still be neglected. The situation changes when higher energy inputs are involved. The effect of mixing can no longer be disregarded, and becomes important in scaling-up. A more rapid decrease of efficiency with column diameter is observed. No general rules can be given.

Symbols Used

a/v = surface/volume ratio of dispersed phase.
C_R = factor accounting for restriction of column by the stator rings and rotor discs in capacity correlation: equal to either S^2/D^2 or $(D^2 - R^2)/D^2$.
D = diameter of column (m).
d = droplet diameter.
E = extraction factor equals (distribution coefficient of solute) × (flow rate of solvent phase)/(flow rate of raffinate phase).
H = compartment height (m).
h_D = fractional hold-up of dispersed phase.
k = mass transfer coefficient.
N = rotor speed (rev./sec.).
P = energy input per rotor disc of contactor.
R = diameter of rotor disc (m).
S = diameter of opening in stator disc (m.).
v_C = superficial velocity of continuous phase (m./sec.).
v_D = superficial velocity of dispersed phase (m./sec.).
η = compartment efficiency, number of theoretical stages.
ρ = density of liquid phase.
τ_D = residence time of dispersed phase in compartments (sec).

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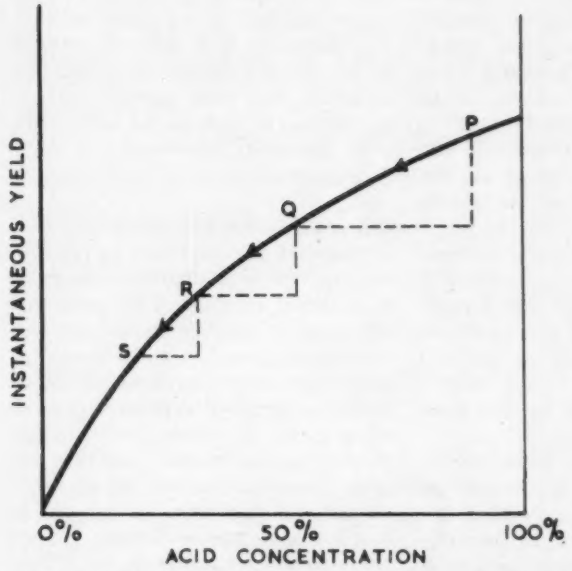

FIGURE 1—When the instantaneous yield falls continuously with more dilution of acid, a flow reactor usually gives a greater yield.

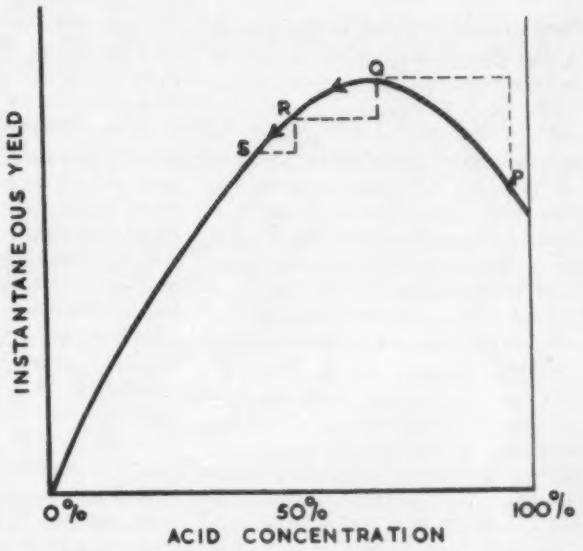

FIGURE 2—When the yield curve has a maximum, it may be better to operate a series of batchwise reactors.

How to Choose Best Reactor Type

Here are some of the points you should consider in choosing whether a reactor is to be batchwise or continuous. The discussion also compares the advantages of two types of continuous reactors.

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IN THE DESIGN OF any large-scale reaction process, the question arises whether the process should be operated batchwise or continuously to give the largest yield. If continuously is better, then it is necessary to decide whether to use a tubular reactor or a set of stirred tank reactors.

The term "yield" is to be understood here in the same sense as in organic chemistry. In other words, it is based on the portion of charge consumed, and not on the output per unit of time and volume.

Batch and tubular reactors. Consider first the relatively small difference between a batch reaction, as used in laboratory work, and continuous reaction in a tubular system. In any element of reacting fluid passing through a tubular reactor there is a continuous change of composition, as in a batch process. However, the fluid elements at different distances from the axis have different times of passage and there also occurs molecular or eddy diffusion from one element to another.

For this reason not all molecules have the same time of passage. Fluid moving near the axis may not react sufficiently and fluid moving near the wall may react for too long a time, especially if there are degradation reactions. This applies particularly if there is laminar flow. (For example in polymerization, using highly viscous liquids, the distribution of residence times would tend to broaden the molecular weight distribution of the polymer, as compared to the same reaction carried out batchwise.)[1]

On the other hand, under turbulent flow conditions the distribution of the residence times is not very large and the assumption of "plug flow" becomes a fairly good approximation. Under such conditions the tubular reaction process is almost equivalent in its chemical kinetics to the corresponding batch process whose duration is equal to the time of passage of the "plug" and which

has the same feed composition and distribution of temperatures.

Continuously stirred tank reactor. A very different situation prevails in the continuously stirred tank reactor (C.S.T.R.). If mixing is almost perfect, as is fairly easily attained in practice, the outflow composition is the same as the composition within the vessel. The stationary concentrations of reagents are therefore much lower than the corresponding average concentrations in the batch or tubular reaction system. This conclusion has two important consequences.

1. The volume of the C.S.T.R. must be much larger than required for a batch or tubular reactor for the same rate of output. To reduce the difference it is customary to use two or more tanks in series, resulting in a stepwise fall of concentration, and

2. The yield of the desired product (which is quite distinct from the degree of conversion of the reagents, if there are side reactions or consecutive reactions), may be either greater or less than in a batch or tubular reaction process. This effect will now be discussed in relation to a selection of the various kinetic factors which may affect the yield.

EFFECTS ON YIELD

Effect of a product of reaction. Consider as an example an organic nitration reaction, in which the yield of the required nitrobody is often very sensitive to the concentration of the nitrating acid, because the speed of side reactions relative to the main reaction is affected by the acid concentration. Moreover one of the products of reaction is water.

$$RH + HNO_3 = RNO_2 + H_2O.$$

This water serves to dilute the acid as reaction proceeds. It follows that the instantaneous yield, which is to say the yield from each infinitesimal amount of RH which is nitrated, varies during the course of the process.

Two important cases arise in practice. The first, illustrated in Figure 1, is where the instantaneous yield falls continuously with increasing dilution of the acid. In a batch or tubular reaction process, if P and S are the initial and final acid concentrations respectively (the value of S being determined by the amount of excess acid which is used), the over-all yield is a weighted mean of the instantaneous yields over the reaction trajectory PQRS. On the other hand, using three C.S.T.R. in sequence, if the feed acid to the first tank is chosen as P, as in the batch process, the stationary acid concentration in the first tank will not be P but will be at some lower value such as Q. In the subsequent two stages the acid concentration will have values such as R and S. The over-all yield will therefore be the weighted mean of the yields obtained at the points Q, R, and S—weighted according to the relative amounts of reaction in the three tanks.

In the second case, illustrated in Figure 2, the yield is at a maximum at a particular concentration of the acid, and the C.S.T.R., if correctly designed, may give a higher yield than can be obtained from batchwise or tubular reactors.

Effect of the Order of Reaction. Consider two competing reactions

$$2A + B = X$$
$$A + B = Y$$

in which X is the desired product and Y is a wasteful by-product. It may be that the two reactions are not of the same kinetic order. Suppose that the reagent B is in large excess and that the rate of the X-forming reaction varies as the square of the concentration of A and the rate of the Y-forming reaction varies as its first power. Thus

$$\frac{dx}{dt} = k_1 a^2 \quad . \quad . \quad . \quad (1)$$

$$\frac{dy}{dt} = k_2 a \quad . \quad . \quad . \quad (2)$$

where a is the momentary concentration of A and dx and dy are the numbers of moles of X and Y respectively which are formed in unit volume in a time dt.

Hence

$$\frac{dx}{dy} = \frac{k_1 a}{k_2} \quad . \quad . \quad . \quad (3)$$

The ratio of the amounts of X and Y formed during the interval dt, and therefore the yield of X, is evidently greater at higher concentrations of A, and will diminish during the course of the reaction.

In this case the batch or tubular reaction processes are to be preferred, since they operate at higher average concentrations, for the same feed conditions. If, for quite different reasons, there are grounds for choosing the C.S.T.R., the yield can be raised—though not as high as the batch yield—by increasing the number of tanks in sequence.

Degradation Reactions. Another example of the possibility of predicting the best type of process occurs in degradation reactions. This name will be given to those reactions in which the required product X can react further to give some unwanted product Y.

The maximum yield of X would occur after a certain duration, no shorter and no longer. Therefore, an ideal plug flow reactor would theoretically produce the best results. A batch reactor or an infinite (effectively infinite) cascade of C.S.T.R.'s could be used, but any practical reactor (which cannot do more than approximate to plug flow) would show this spread of residence times to a greater or less extent.

For successive reactions

$$A + B \rightarrow X \rightarrow Y \rightarrow Z,$$

the reader is referred to MacMullin's paper[3] and also to Corrigan and Young.[4]

Optimum Temperature Profiles. So far the yield has been discussed in terms of the influence of composition and the spread of residence times. It has perhaps not been sufficiently realized that the yield of a complex reaction may often be appreciably improved by making a continuous change of temperature during the course of the reaction.[2] For this purpose the tubular reactor is in some respects the most convenient, although a controlled change of temperature can also be applied during the course of a batch process. In a C.S.T.R. of several tanks in sequence, each tank can be held at a fixed temperature, with stepwise change from one to the next, but this is less effective in principle than a continuous variation.

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Scale Up Continuous Filters This Way

To scale up filtration equipment, check this method for correlating and extrapolating laboratory data. It will help you in your decisions concerning laboratory filtration variables.

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THE AIM OF this paper is to describe scale-up methods which are of general application to continuous filtration equipment. Although occasional references to the details of particular types of filter are essential, it is not intended to describe the many different kinds of filter. This subject has already been well treated in the literature.[1, 3, 4, 5, 6, 8, 9, 10, 11, 12]

To understand the approach, it must be understood that all continuous vacuum or pressure filters depend upon the same basic principle of a cyclic process composed of at the most five stages:

1 cake is formed,
2 cake is dewatered to a particular moisture content,
3 cake is washed to remove valuable or undesirable solubles,
4 cake is dried thermally, and
5 cake is discharged.

(Editor's note: Only the first step or cake formation is primarily important to a refiner. Therefore, we will report only the part dealing with this phase of filtration.)

Filtration data may be obtained either on laboratory scale, using what is known as the "leaf-test procedure"[4, 6, 7, 13, 14] or on pilot plant. Even if pilot-plant work is intended, it is always advisable to carry out a preliminary leaf-test investigation since the flexibility of the method enables the many variables to be examined rapidly. For this reason, the following discussion of how data may be correlated and extrapolated generally refers to leaf-test investigations but the same principles are naturally applicable to pilot-plant work.

It must be emphasized that attention is here devoted to data obtained from a slurry in its existing condition. It frequently occurs that the filtration characteristics of a slurry may be improved by such means as pH adjustment, the addition of flocculating or wetting agents, or preliminary thickening. While such methods of pretreatment are often very useful, it is not intended to discuss them in this paper.

Scale-up from Cake Formation Rate

Theoretical background. Although more rigorous equations have been developed, the well-known modification of the Poiseuille equation[2] enables the important variables to be correlated simply:

$$\frac{dV}{Ad\theta} = \frac{\Delta P}{\mu\left(\frac{\alpha w V}{A} + r\right)} \qquad (1)$$

Equation (1) gives the instantaneous filtration rate after a volume, V, of filtrate has passed through the filter. To apply it to the cyclic process of continuous filtration, the equation must be integrated. Before doing this, the resistance terms will be discused briefly.

With proper hydraulic design the resistance of the internal piping and drainage system can be made negligible and will be so assumed in this paper. Following common practice, it will also be assumed that the resistance of the filter medium is negligible although it is realized that this is not always true, either where the medium is very tight or where it is partly blinded. It will be seen below, however, that this assumption can often be justified by actual data.

The specific cake resistance, α, is unfortunately not constant but is influenced by many factors, the most important being:

1 particle size distribution,
2 particle shape characteristics,
3 cake homogeneity,
4 solids orientation in the filter cake,
5 feed solids concentration, and
6 pressure drop.

For a particular slurry, provided proper care is taken to form a homogeneous cake, the first five factors can generally be regarded as constants. Failing this, they must be handled as parameters since no satisfactory theoretical relationship has been established. The influence of pressure drop, however, has been expressed mathematically in the form of Equation (2):

$$\alpha = \alpha' (\Delta P)^s \qquad (2)$$

From the above discussion, Equation (1) is restricted by certain parameters and, after simplification, can be integrated between the limits $\theta = 0$ and θ_t and $V = 0$ and V_t (where V_t is the volume of filtrate obtained in cake-forming time θ_t).

$$V_t/A = \left[\frac{2(\Delta P)^{(1-s)}\,\theta_t}{\mu\alpha' w}\right]^{1/2} \qquad (3)$$

Equation (3) expresses filtration rate in terms of one cycle or revolution of the filter, whereas it is more convenient to utilize a time basis.

This can easily be done by dividing through by the cycle time, θ_c; since $\theta_f = B \times \theta_c$ where B is the fraction of the cycle devoted to cake forming, we obtain

$$\frac{V_f}{A\theta_c} = Y = \left[\frac{2(\Delta P)^{1-s} B}{\mu \alpha' w \theta_c}\right]^{1/n} \quad (4)$$

where Y is the filtration rate expressed in volume of filtrate per unit area per unit time. By multiplying this by a conversion constant, the filtration rate may be expressed in weight of cake per unit area per unit time.

Equation (4) shows how the variables would be expected to affect filtration rate.

Cake formation time. The cake formation time $\theta_f = B \times \theta_c$ thence θ_f may be altered either by varying B or by varying θ_c. Equation (4) shows that at constant B, filtration rate is inversely proportional to the square root of either θ_c or θ_f; therefore, a plot on logarithmic coordinates of Y as a function of θ_c or θ_f should give a straight line of slope—0.5. Similarly, at constant cycle time (θ_c), the filtration rate is directly proportional to $\sqrt{B}$ and a similar plot should therefore give a straight line of slope + 0.5.

In practice, straight lines are usually obtained, thus showing the validity of the assumption concerning the filter medium resistance term, r, in Equation (1). The slopes of the lines frequently deviate from ± 0.5, however, due to the specific cake resistance α altering during the filtering cycle, probably because of the migration of fines within the cake.

For example, in an investigation of the filterability of melamine crystals in aqueous ammonia, a logarithmic plot of dry solids per hour per square foot as a function of cake-formation-time gave a straight line of slope — 0.617. Examination showed that the equation for the line was

$$Y = 56.0\,(\theta_f)^{-0.617} = 56.0\,(\theta_c B)^{-0.617} \quad (5)$$

In this instance, where a bottom-fed vacuum drum filter was used, B=0.25 since the need for washing and dewatering allowed only 25 percent of the cycle for cake formation. In the final calculation, a scale-up factor must be included to allow for deviation between leaf-tests and full-scale results, due largely to gradual blinding during the life of the filter medium. The exact value of this factor varies, depending upon the nature of the solids and the care of cake discharge, but most values lie between 0.7 and 0.8 with the majority being the higher value. Hence a reduced form of Equation (5) may be stated:

$$Y = 105.3\,(\theta_c)^{-0.617} \quad (6)$$

To allow flexibility for handling poor-quality product, it was decided in this instance to base design on a ¾ in. cake. Tests had shown this could be formed in 0.75 min., equivalent to 25 percent of a three minute cycle. The design filtration rate was thus 53.4 pounds dry solids per hour per square foot, while the output at any other cycle time could be rapidly calculated from Equation (6) and variations due to submergence could be calculated from Equation (5).

Slurry concentration. Equation (4) predicts that filtrate rate is inversely proportional to $\sqrt{w}$, which is a function of slurry concentration. Similarly, cake filtration rate is directly proportional to $\sqrt{w}$. Such predictions cannot safely be made in practice, however, since α often decreases with increasing slurry concentration due to a more open cake being formed. It is therefore always advisable to investigate the influence of this factor experimentally.

Pressure drop. Equation (4) predicts that filtration rate is directly proportional to $(\Delta P)^{\frac{1-s}{2}}$, where s is the cake compressibility factor and varies from 0 to 1.0. Hence, with an incompressible cake, where $s=0$, filtration rate is proportional to $(\Delta P)^{0.5}$; and with a completely compressible cake, where $s=1$, filtration rate is independent of ΔP.

In practice, most materials lie between these extremes, but, nevertheless, a logarithmic plot of filtration rate as a function of ΔP gives a straight line relationship for which an equation may be developed similar to Equation (6). Economic studies may then be made to balance increased vacuum pump or compressor costs against savings in filter costs. As the exponent of ΔP decreases, the economic pressure drop also decreases, being generally 40-60 pounds per square inch where the exponent lies between 0.35 and 0.50.

Viscosity. Practical experience usually conforms to Equation (4) which predicts filtration rate to vary inversely with the square root of filtrate viscosity. The most common way of altering viscosity is to change the temperature. Since viscosity/temperature data are either available in the literature or are readily measured, it is therefore simple to extrapolate filtration data from one temperature to another, provided no other factor, such as particle size, is also changed.

SYMBOLS USED

A = area.
B = fraction of filter cycle employed for cake formation.
r = resistance of unit area of filter media plus internal piping, etc.
s = cake compressibility exponent on ΔP ranging from 0.0 for non-compressible cakes to 1.0 for highly compressible cakes.
V = volume of filtrate.
V_f = volume of filtrate at θ_f.
w = weight of dry cake solids per unit volume of filtrate.
Y = filtration rate expressed as

$$\frac{\text{Vol. Filtrate}}{\text{Hour} \times \text{Unit Area}}$$

or

$$\frac{\text{Weight Dry Cake Solids}}{\text{Hour} \times \text{Unit Area}}$$

α = specific cake resistance.
α' = specific cake resistance at $\Delta P =$ 1.0. Derived from $\alpha = \alpha' (\Delta P)^s$.
ΔP = pressure drop across filter.
θ = time.
θ_c = filter cycle time.
θ_f = cake formation time.
μ = filtrate absolute viscosity.

Unless otherwise specified, any consistent system of units may be employed for nomenclature.

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Be Careful Scaling Up Gas Absorption Data

The author discusses some of the reasons full-scale gas absorption plants do not operate as predicted from laboratory data.

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GAS ABSORPTION in some full-size columns may amount to only about 25 percent of that predicted on the basis of pilot plant work. This article discusses some of the factors which cause the wide difference in scaling-up.

Liquid Flow. The flows over two absorption beds are similar if they have the same Reynolds numbers and the same Froude numbers.[1] These dimensionless numbers are defined as follows:

$$\frac{uD\rho}{\mu} = \text{Re} = \text{Reynolds number.}$$

$$\frac{Dg}{u^2} = \text{Fr} = \text{Froude number.}$$

If subscripts 1 and 2 are used for denoting the quantities pertaining to the two beds

$$\frac{u_1 D_1 \rho_1}{\mu_1} = \frac{u_2 D_2 \rho_2}{\mu_2} \text{ and } \frac{D_1 g}{u_1^2} = \frac{D_2 g}{u_2^2}$$

from which it follows that:

$$\frac{\mu_1 \rho_2}{\mu_2 \rho_1} = (D_1/D_2)^{3/2}$$

since for most liquids ρ is about equal to 1 g./cc.:

$$\mu_1/\mu_2 \simeq (D_1/D_2)^{3/2} \quad . \quad . \quad . \quad (1)$$

It is often impossible to satisfy this requirement. If, for instance, in a technical apparatus 1 inch rings were irrigated with water, model experiments using 1/5 inch rings would require the use of a liquid having a viscosity of 0.09 Centipoises, which is practically impossible.

The requirements of similarity are still more difficult to satisfy if the surface tension σ is taken into account. This leads to the requirement that:

$$\frac{\sigma_1}{g\rho_1 D_1^2} = \frac{\sigma_2}{g\rho_2 D_2^2}$$

which, if ρ remains unchanged, implies that:

$$\frac{\sigma_1}{\sigma_2} = \left(\frac{D_1}{D_2}\right)^2 \quad (2)$$

Although in some cases it may be possible to satisfy requirement (1), it is very unlikely that a model liquid will be found which satisfies both requirements (1) and (2). Therefore absorption experiments should be carried with technical-size packing material.

Liquid Distribution in an Irrigated Packed Column. There is a certain minimum value of the ratio between the column diameter D_c and the diameter of the packing bodies D. Empirically determined minimum values of D_c/D can be found in literature.[2,3] It is there stated that D_c/D should be greater than 10. When 1-inch rings are used the experimental column should be given semi-technical dimensions. In the experiments carried out in the Central Laboratory, it was found that the variation in the irrigation of individual packing bodies lying at equal distances from the axis in the same horizontal cross sectional plane is much greater than the differences between the mean values of the irrigation for distinct concentric rings.

A measure of the absorption efficiency is the quantity $k_L a$, the coefficient of mass transfer in the liquid per unit of volume of the column. In order to express the relation between $k_L a$ and u, van Krevelen and van Hooren[4] used the equation:

$$\frac{k_L a}{a_p D_L} = c\left(\frac{u\rho}{a_p \mu}\right)^{0.5} \left(\frac{\mu}{\rho D_L}\right)^{0.4} \quad (3)$$

where the diameter of the packing bodies, D, has been replaced by the reciprocal value of a_p, the total surface area per unit volume of the packing material. The experiments carried out by Sherwood and Holloway[5] on the desorption of oxygen from water in a packed column proved to be well covered by Equation (3).

Series of laboratory experiments and semitechnical measurements on the absorption of carbon dioxide in water are reported in Figure 1. This figure shows the wide deviation which results from different packing size.

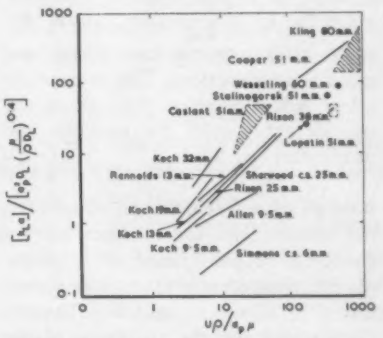

FIGURE 1—Packing sizes cause a wide deviation when absorption correlations are attempted.

SYMBOLS USED

- a = active surface per unit volume ($m.^{-1}$).
- a_p = total surface per unit volume ($m.^{-1}$).
- c = constant.
- D = diameter of packings (m.).
- D_c = diameter of column (m.).
- D_L = diffusivity in liquid (m^2. $sec.^{-1}$).
- g = acceleration of gravity (m. $sec.^{-2}$).
- k_L = liquid mass transfer coefficient (m. $sec.^{-1}$).
- u = velocity (m. $sec.^{-1}$).
- μ = absolute viscosity of liquid (kg. $m.^{-1}$ $sec.^{-1}$).
- ρ = density of liquid (kg. $m.^{-3}$).
- σ = surface tension (kg. $sec.^{-2}$).

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Estimate Cyclone Size

The pressure drop and separating performance of a cyclone may be figured by the method described here.

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LARGE CYCLONE separators can represent high capital investments. Establishing the proper size of cyclone with full-scale tests may be impossible, therefore, reliable methods are needed to scale-up laboratory data.

At equal Reynolds numbers given by $Re = \frac{V_0 D_1}{v}$ cyclones of the same geometric design show the same flow pattern. At equal Froude numbers given by $Fr = \frac{V_0^2}{D_1 g}$ they show the same ratio between centrifugal and gravity acceleration. The separating effect will depend on the ratio of the specific gravities of the particles and of the carrying fluid.

Design of a Cyclone. In many cases the model laws for cyclones do not enable a proper choice to be made of the design, nor of cyclone properties.[1,2,3] However, by using Taylor's calculation[2] for the thickness of the boundary layer, some data may be computed.[4]

Defining a flow factor α by

$$Q = \alpha F_0 \sqrt{\frac{2\Delta P}{\rho}}$$

the probable pressure loss at a given load Q may be calculated from:

$$p_0 - p_2 = (\alpha^{-2} - 1) \cdot \tfrac{1}{2} \rho V_0^2 + \tfrac{1}{2} \rho V_2^2 \qquad (1)$$

provided α is known. For a given cyclone α may be computed from simple quantity and pressure measurements. It then appears that α is a function of the Reynolds number of the cyclone. This function may be expressed by the formula:

$$\alpha = \frac{\alpha_\infty}{1 - \frac{1}{6} G \frac{F_1}{F_0} \sqrt{\left(\frac{2}{Re \sin \gamma}\right)}} \cdot \qquad (2)$$

where α_∞ is the flow factor of a cyclone fed with an ideal fluid. $Re = \infty$ for such a case.[5] The term

$$\frac{1}{6} G \frac{F_1}{F_0} \sqrt{\frac{2}{Re \sin \gamma}}$$

is a correction for the boundary layer.

To determine α_∞ proceed as follows: calculate

$$\frac{F_0}{F_2} \cdot \frac{D_2}{D_1}$$

and read the corresponding value of

$$\frac{\xi^3 \sqrt{2}}{(1+\xi^3)^{1/2}}$$

from Table 1.

TABLE 1

$\frac{F_0}{F_2} \cdot \frac{D_2}{D_1}$	ϵ	$\frac{\epsilon^2\sqrt{2}}{(1+\epsilon^3)^{1/2}}$
0.525	0.700	0.568
0.489	0.710	0.581
0.472	0.715	0.588
0.443	0.724	0.600
0.425	0.730	0.609
0.402	0.737	0.619
0.378	0.745	0.629
0.298	0.775	0.672

Using the formula

$$\frac{F_0}{F_2} \cdot \frac{D_2}{D_1} = \frac{(1-\xi^3)^{1/2}}{\xi^3 \sqrt{2}},$$

this table may be extended at will by substituting various values for ζ and calculating the first and third columns.

α_∞ is calculated by:

$$\alpha_\infty = \frac{D_2}{D_1} \cdot \frac{\xi^3 \sqrt{2}}{(1+\xi^3)^{1/2}}.$$

The value of G can be taken from Table 2.

TABLE 2

D_2/D_1	G
0.50	9.880
0.45	10.445
0.40	10.900
0.35	11.397
0.30	11.797
0.25	12.198
0.20	12.483

Equation (2) for α does not include a single experimental datum, but has been derived exclusively from a stylised concept of the flow pattern in the cyclone. In developing this concept it was assumed that the flow in the cyclone equals that of an ideal fluid, except in the boundary layer along the wall.

When

$$\frac{1}{6} G \frac{F_1}{F_0} \sqrt{\frac{2}{Re \sin \gamma}} = 1, \alpha = \infty,$$

which gives a Reynolds number of

$$Re_{cr} = \frac{G^2}{18 \sin \gamma} \left(\frac{F_1}{F_0}\right)^2$$

which we shall call *the critical Reynolds number of the cyclone.*

Experiments have shown that if the cyclone is to give a good performance under the operating conditions, the actual Reynolds number should be an order of magnitude higher than this critical number which depends exclusively on the dimensions of the cyclone.

For the separating performance of the cyclone, assume the diameter of the largest particle which cannot be caught is a measure of the performance. It has been found that this diameter may also be derived by calculation only. This minimum dimension may be found using the formula:

$$d_0 = D_2 \left[0.349 \, Re \frac{(D_1 - \xi D_2)}{b_0} \left(\frac{\rho'}{\rho} - 1\right)^{-1/2} \right] \cdot \qquad (3)$$

where ζ is a function of D_0, D_1, and D_2 as given in Table 1.

SYMBOLS USED

a_0 = height of feed aperture.
b_0 = width of feed aperture.
d = particle diameter.
D_1 = cyclone diameter.
D_2 = diameter of overflow aperture.
D_3 = diameter of apex aperture.
F_0 = area of feed aperture.
$F_1 = \frac{1}{4}\pi D_1^2$.
F_2 = area of overflow aperture.
F_3 = area of apex aperture.
g = acceleration due to gravity.
H = over-all length of the cyclone.
h_1 = height of cylindrical section.
h_2 = length of vortex finder.
P = difference in total pressure before the cyclone and after the overflow aperture.
Q = capacity $= V_0/F_0$.
V_0 = inlet velocity, $V_2 = Q/F_2$.
α = flow factor.
γ = half apex angle.
v = kinematic viscosity.
ρ = density.

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How Engineer-Contractors Handle a Job

To get the most for your process construction dollar, it pays to know how your engineer-contractor is organized. Here are the steps to job completion.

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WHAT DOES an engineer-contractor do?

How does he go about developing an inquiry into a finished process plant?

Proper answers to these questions will help you get more for your construction dollar and here are the reasons why. Engineer-contractors provide important services in helping the refining and petrochemical industries continue their rapid growth. These companies design, engineer and purchase equipment for the construction of process plants. They have available technical specialists for process design and development; engineers for detailed design; experts for purchasing, expediting and inspection of material; an experienced staff of construction personnel.

The steps followed by an engineer-contractor in applying these technical skills, from the first inquiry to a finished process plant, is the basis for this article.

Here's how engineer-contractors function.

THE INQUIRY

In general, there are three types of inquiries, consisting of the following:

Preliminary inquiries usually result from a company which believes its present processing routes are obsolete; wishes to expand into new fields; has an excess of raw materials and wishes to find an economical route by which they can use the excess raw materials to the greatest advantage; or an individual who believes that there is a market for certain products and wishes to determine if a plant can be economically constructed and operated to furnish products to meet this market.

Usually the information is desired in a very short period of time and a high degree of accuracy is not required.

Formal inquiries ordinarily develop from the preliminary inquiry after the purchaser has made his evaluation of various routes that can be followed and finally decides that one route is more advantageous than the other, and wishes to obtain a definite proposal for performing this work.

Hardware type of inquiries result from the owner having prepared complete process designs, defining all mechanical equipment as to size, quantity, capacity, and quality of materials.. Since the entire scope of the proposed project is defined, no

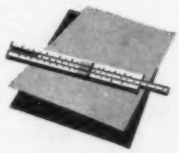
latitude is given to the bidder and the proposal must be based on the inquiry.

THE PROPOSAL

Proposals can be, in general, broken down into two types:

Preliminary proposals are made in reply to the preliminary inquiry or as a sales effort. Often, only the contractor's sales engineer, who from cost curves, can furnish the necessary information, is involved in its preparation. Usually the proposal is made by furnishing the customer with a very short letter stating the approximate cost, the approximate yield, the approximate time of completion, and sufficient information to allow the customer to compute the operating costs. This letter also expresses the willingness and desire on the part of the contractor to furnish a firm proposal as soon as information is available for the development of same.

Formal proposals are made in reply to the formal inquiry. They are developed from the basic data contained in the inquiry. The proposal includes statements in reference to the capacity of the plant, the charge stock, the yields, the location of the plant, and usually also includes complete process flow diagrams, piping and instrument flow diagrams, specifications, plot plan, and general arrangement drawings. Prices and estimated time required to design, procure, and construct the plant are given and, in some instances, guarantees and limits of liability are also given.



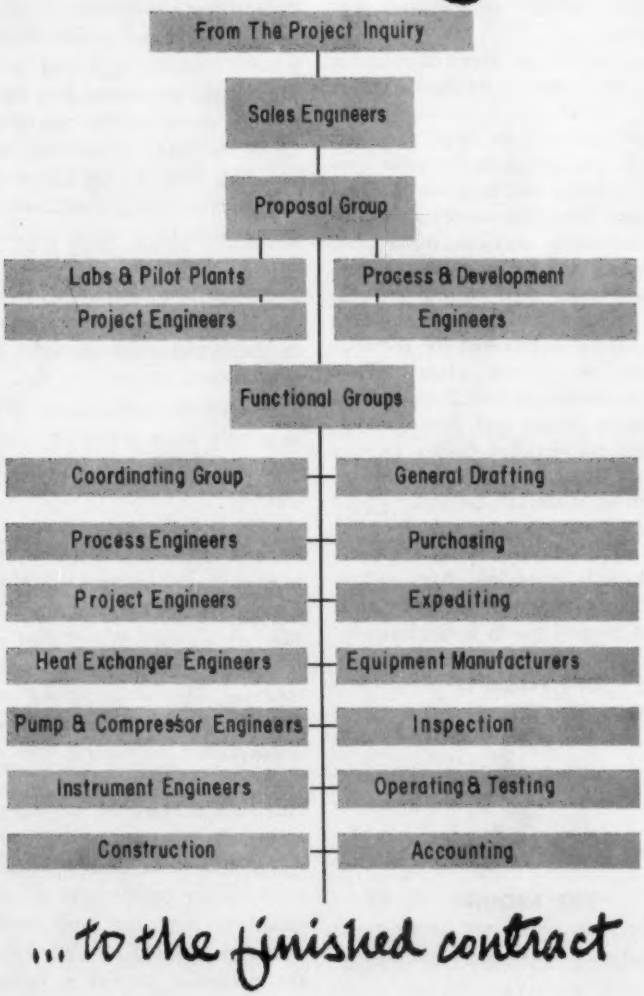
ESTIMATING

Estimating requirements follow almost exactly the type of proposal as far as scope of work is concerned. As stated before, the estimating for a preliminary inquiry is largely made from curves. The curves are based on return costs of similar units and the curves are plotted with capacity as one axis, and cost for the other axis. The data making up the curve are valid for only one particular year and factors must be applied to compensate for escalation, location, alloys, and similar variables.

Material estimating for a formal proposal must be made to a high degree of accuracy. Actual quotations are obtained for all major equipment because of price escalation. Other than major equipment, all other equipment and material information is taken off drawings and flow diagrams in great detail and individually priced. The quotations and estimated prices are extrapolated to the time when it is contemplated the equipment and materials will be purchased. A total material estimate results.

Labor estimate is prepared in much the same manner as the material estimate. Consideration must be given

How a Contractor is organized...



... to the finished contract

to all major equipment as to size, type of materials, shop fabricated or field fabricated, and location—as each has a marked effect on labor required for erection. Return labor costs or manhours, available from previous similar jobs, are used to the fullest extent possible. The actual location of the facility must be taken into consideration because of varying labor productivity due to local and climatic conditions.

Field organization necessary to perform the work must be carefully developed before an estimate can be made. Items to be considered include amount and quality of supervision, field offices, warehouses, shops and other temporary facilities, distribution of personnel and equipment, construction equipment, tools and supplies, testing, and the length of time the field organization will be required.

Office costs must also be estimated with great care to determine the cost of accounting, engineering, drafting, purchasing, expediting, and inspection.

Contingency. After the basic costs are established and extrapolated to provide for future change in costs, it is necessary to add to these costs a contingency to provide for conditions that might arise during the life of the job and which are not known at the time the estimate is being prepared.

Fee. With all costs determined, the contractor's fee to provide for his overhead and profit is added and the result becomes the selling price to the customer.

Revisions. In many instances, after the selling price is submitted to the customer, it becomes necessary to revise the price to provide for up or down grading of specifications and additions or deletions to the scope of the work.

A control estimate is prepared for each project. This estimate establishes the amount of money that is available for each code of account, both materials and labor, and both office and field. With the control estimate the project engineer can determine at all times the status of the job and take all possible measures to maintain the cost of the project within the required limits.

THE CONTRACT

There are almost an infinite variety of contracts; however, they can be classified into four general types, as follows:

Cost Plus a Percentage. All direct costs are reimbursable and a percentage of direct cost is allowed as a fee to cover contractor's overhead and profit. A checklist is provided as part of the contract to define both direct and indirect costs, and costs to which the fee percentage is applied. In some instances, the fee percentage varies, depending upon whether the costs are office or field, materials, labor or tools, process units or facilities other than processing units. In addition, the fee also varies with the total value of the job—usually decreasing with increase in total cost.

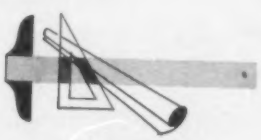
Cost Plus a Fixed Fee is the same as cost plus a percentage contract, except that, instead of a fee being a percentage of costs, it is a fixed amount. The fixed fee type of contract presupposes that the scope of the work is fixed, thus enabling the contractor to estimate the cost of the work with a reasonable degree of accuracy and, from the estimate, determine the fee. Usually, means are provided in the contract to increase or decrease the fixed fee, should the scope of the work change. Checklists defining cost are also part of the contract.

Guaranteed Maximum. The contractor guarantees to furnish certain facilities or services for a guaranteed maximum amount. The contract must define the scope of the work accurately, not only as to capacity, but also as to the quality of materials that are used in construction and the flexibility required for operation and maintenance. Should the facilities cost more than the guaranteed maximum, the additional costs are borne by the contractor. Should the facilities cost less than the guaranteed maximum, the difference in cost is usually shared on a 50-50 basis by the owner and contractor. Checklists to define cost and provisions to allow for changes in the scope of the work are made part of the contract.

Turnkey. The contractor guarantees to furnish certain facilities for a fixed amount. Here again, the scope of the work is accurately defined and provisions are made in the contract for changing the scope of the work. Should the facilities cost more than provided for in the contract, the additional cost is borne by the contractor. Should the facilities cost less than provided for in the contract, the difference represents the contractor's overhead and profit, and is not shared with the owner.

Guarantees. For any of the above types of contracts, it is necessary to define Guarantees accurately. Aside from the monetary guarantees, it is usual for the contractor to provide guarantees for quantity and quality of products, based on well defined charge stocks. Guarantees are usually given for equipment covering capacity and efficiency and freedom from design and construction errors. In those instances where a licensed process is incorporated in the facilities, it is usual for the licensor to make guarantees direct to the owner, since the owner arranges with the licensor for the use of the process.

Liabilities. The contract provides for liabilities assumed by the contractor. The liabilities covering workmen's compensation, comprehensive general public liability, comprehensive automobile liability, and property damage are usually liabilities of the contractor and are covered by insurance. Fire and extended coverage are usually liabilities of the owner and are covered by his insurance. The contractor's liability for meeting performance guarantees is usually limited to a percentage of the contractor's fee.



JOB DESIGN

As soon as a proposal is accepted and becomes a job, it is necessary to appoint a project engineer as the contractor's representative through whom all information is handled and who becomes the responsible representative of the contractor to fulfill

the obligations of the contractor. It is also necessary to appoint a process engineer to head up the development of all process work. The project engineer and the process engineer work as a team throughout the development of the work. The first duty of the project engineer is to prepare job instructions which define the methods to be used in handling the work.

Job Instructions. The problem of translating a contract obligation into an operating plant requires that lines of authority and communication, in both the customer's and contractor's organizations, be firmly established as soon as possible. Likewise, basic design data must be established. In an endeavor to accomplish this, a standard form of job instructions has been developed and all job instructions start with this form.

It may appear that the job instructions are too routine, but this is not the case because, unless one person is set up in each of the organizations to approve the work, the job soon bogs down. If standard distribution for dispensing information is not established, then the receipt of the information is delayed and, in some cases, is never acted upon. It has been determined that the job instructions, instead of being a burden, actually speed up the orderly handling of a job and reduce duplication of effort.

Job Schedules. In every instance a tentative job schedule, particularly as it applies to completion date, is a condition of the contract, even though it might not be a guaranteed date. In some instances, the contract provides for a guaranteed completion date, with bonuses and penalties to cover liquidated damages to be applied respectively for each day before and after the date on which the work is completed. To assure the completion date being met, it is necessary to prepare schedules covering each phase of the work.

The basic data required for preparation of the schedules consists of: first, the time at which the information will be available to allow process design to begin; and second, the length of time required to perform the process design. With this information, dates can be established for the release of major equipment to the requisitioning sections for the start of the purchasing.

The major equipment normally consists of heaters, heat exchange equipment, pumps, compressors, pressure vessels, and electrical equipment. It is known from past experience how long it requires a vendor to submit his proposal and the time required for reviewing and selecting a vendor. This information is used to determine the time required to purchase. The latest information available from vendors likewise determines the lead factor for delivery of equipment. Usually, the major equipment controls the construction completion date.

Certified drawings from the equipment manufacturers are necessary before final detail drawings can be prepared for foundations, piping and, in some instances, pressure vessels. As soon as dates can be determined for the receipt of these certified prints, a firm drafting schedule can be prepared for a normal job. A complete schedule, showing all functions that must be performed from the time the contract is awarded until the work is turned over to the customer, can thus be prepared as soon as dates can be fixed for the release of process information procurement time, receipt of certified prints and receipt of major equipment.

From the over-all schedules, detailed schedules can be prepared showing manpower required for detailed drafting and for the construction force required in the field. Of course, the actual completion date determined for the over-all project must not only be realistic as far as material deliveries are concerned, but consideration must be given to the ability of the project, process and drafting room personnel to complete their design work in ample time for the field forces to complete the field work. Likewise, the period available for field construction must allow sufficient time for a reasonable number of men to perform this work. Some schedules have been made which would require such a concentration of manpower that it would be impossible to accommodate the men in the area available. Careful study by experienced personnel will prevent this condition from arising.

Process Design in a contracting organization usually covers a wider scope than in manufacturing companies. Process design covers the interpretation of laboratory, pilot plant, or commercial plant data for setting up the basis for some processing unit. After the basis has been established, chemical engineering calculations such as equilibrium, heat and material balances, and pressure drops, are made. After the basic flows and heat requirements and the various process

Process Designers Take These Steps

1. Basic design data—he gets from refiner or his laboratory if it's not already available.

2. Process flow diagrams—he shows quantities, temperature and pressure conditions as well as sequence.

3. Process Sketches—he shows mechanical designer basic info vessels.

4. Equipment schedules—he tabulates details on pumps, compressors, exchangers and vacuum equipment.

5. Instrument data—he tabulates type of control desired along with conditions.

6. Block flow diagrams—he gives basic data for design of utility systems.

conditions as to temperature, pressure and the state of the material being processed have been established, individual pieces of equipment can be designed.

It is a prevalent concept that process design stops at this point; however, in a contracting organization, the process engineer is responsible for such things as line sizing, checking the physical design of a unit, and reviewing the equipment to be installed in the plant, so that all components of the plant will ultimately perform the desired processing requirements satisfactorily.

The procedure to obtain this desired result is carried out as follows:

1. Basic Design Data and information are obtained for process design by a contracting organization by several means. If called upon to design a unit which is utilizing a process that is being commercially practiced, and the contractor has operating information, this operating information is utilized for establishing the design of the new unit. If the contractor is designing a unit in which the process is licensed, then he receives the basic data from the licensor as the basis for the design. In cases in which neither of the above apply, the contractor may, within his own research organization, perform the necessary laboratory or pilot plant work for obtaining the fundamental data. This fundamental data consists of information concerning the yields of products which will be obtained when raw materials are subjected to certain conditions such as varying temperature, pressure, contacting time, catalytic action, etc. The engineer correlates these data into a usable form such as a graph, which is a convenient method for extrapolating beyond the known data.

After the basic design data have been obtained, the process engineer then establishes the requirements for the various pieces of equipment in the unit being designed. This information is transmitted to various groups within the organization to enable them to carry on their functions of design of a plant. This transmittal is by the use of simple flow diagrams, sketches and standard forms.

2. Process Flow Diagrams are prepared which shows the flow of raw material to various process equipment, how the equipment is interconnected, and the flow of products leaving the plant. The process flow sheet also shows quantities, temperature and pressure conditions existing throughout a unit, as well as the physical size of vessels, and capacities of pumps and compressors.

This type flow sheet only shows the process requirements and does not show spare pumps, number of heat exchanger shells required, instrumentation, or all the piping required for an operating plant. This process flow diagram is used as a basis for making a piping and instrument flow diagram which defines all of the equipment and piping which is to constitute the plant.

3. Process Sketches are used to transmit information for the mechanical design of vessels such as fractionating towers, reactors, and accumulators. A standard form on reproducible paper is used. For example, the form for vessels consists of a portion left blank for making freehand sketches, and a printed section which allows the process engineer to fill in the pertinent design criteria, e.g., operating and design temperatures and pressures, corrosion allowance, type of material of construction, number and size of nozzles, etc. For fractionating towers information required for the mechanical design of a tray must be included. Another standard form is used for bubble trays and includes the number and size of bubble caps and the area required for downcomers.

4. Equipment Schedules are used to transmit the process requirements for pumps, compressors, exchangers and vacuum equipment.

The pump schedule contains the item number; the service of the pump; the material being pumped; the pertinent operating data, such as the quantity to be pumped, the suction and discharge pressure; the type of pump and its driver; and the overdesign capacity required above the process requirements. From this information, a pump engineer selects a pump which will meet the above mentioned requirements.

Compressor schedules contain similar information, except that the characteristics of the gas to be compressed, rather than the characteristics of the liquid, must be defined.

An exchanger schedule contains the information necessary for an exchanger rater to carry on his calculations for determining the amount of surface required for a specific exchange problem. The schedule prepared by the process engineer defines the quantity of hot and cold materials being handled, the temperature through which this material is heated or cooled, the total amount of heat to be transferred, and the physical characteristics of the material being heated and cooled. This schedule also contains information pertaining to the materials to be used for constructing the exchanger and any other pre-established facts such as the size and thickness of tubes to be used, the length of tubes and any limitations as to the over-all exchanger size.

A vacuum equipment schedule contains the information necessary for an engineer, experienced in vacuum equipment work, to design to meet the conditions specified. These schedules contain quantity and characteristics of the material to be evacuated, the vacuum to be attained, and the pressure at which this equipment must discharge. In the case of vacuum equipment which is to be operated by utilizing steam, the steam conditions are specified. If the vacuum equipment is to be some type of mechanical compressor, then the motivating force is specified.

5. Instrument Data necessary for those engineers experienced in the design and application of instruments to select the best instruments for a specific application is supplied by the process engineer. This information consists of the type of control desired, i.e., temperature, pressure or flow control. Again a standard form is prepared which specifies the flowing quantities, the physical data of the material passing through the control valve, the anticipated range at which the instrument should operate properly, and other pertinent facts, such as the allowable pressure drop for the control valve.

6. Block Flow Diagrams of various types are used for conveying general information concerning parts of a unit or a complete plant. One type of block flow diagram found useful is for showing how a utility system, e.g.,

steam, is basically designed. This type of diagram shows in block form the steam used in a given unit. Often various pressure levels of steam are used in one unit. The block flow diagram shows a complete steam balance. Various steam users within a unit may be utilizing 600 pounds steam which may be bled through a turbine producing 150 pounds steam, while other users may be utilizing 600 pounds steam for discharging to a condenser producing condensate. Although a steam system might be quite complicated, with the use of these block flow diagrams, the overall utilization of steam can be visualized very rapidly.

Another type of block flow diagram is used when a complete refinery is being designed. Its purpose is to show how the several units making up the plant are interconnected. It also shows the complete material balance for the plant being designed. A simple example of such a diagram might be for a refinery which contains crude and vacuum distillation, catalytic cracking, coking, and vapor recovery units. Each of these units is represented by a block with a line showing crude oil going to the crude unit, the several products obtained from the crude unit, and the material from the crude unit which goes for further process to the coking and catalytic cracking units. Here again, by the use of such a diagram, a rapid visual inspection of the entire plant can be obtained.

Mechanical Design consists of five important categories as follows:

1. **Specifications** must be available to determine the quality of materials and workmanship for each project. The quality of specifications varies with the customer and also, greatly with the process and charge stocks. The minimum specifications are, or should be, those dictated by API, ASME, State and National Codes. These codes usually refer to the American Society for Testing Materials Specifications as the measure of quality. The national, state and local codes and insurance regulations give minimum requirements for disposition of equipment, define areas which are considered hazardous and require equipment and materials meeting these hazardous conditions. Charge stocks likewise affect the quality of materials, as some are considered non-corrosive, requiring only carbon steel materials, while others are highly corrosive, requiring expensive alloys. Before a suitable set of specifications can be prepared, all of the above requirements must be taken into consideration.

It is for this reason that it is necessary to prepare or select from standard specifications those specifications that will be applicable to each particular project.

Specifications are normally prepared under the general headings of:

a. *Structural*—which includes foundations, reinforced concrete and structural steel structures, roads, paving, etc.

b. *Pressure Vessels*—including fractionating equipment, reactors, accumulators and storage vessels.

c. *Piping*—here it is necessary to prepare specifications for each individual piping classification such as air, water, steam, oil, chemical, corrosive, non-corrosive, and sub-specifications to provide for extremely high or low temperatures and pressures.

d. *Instrumentation* — Instrument specifications state the type of instrumentation to be used under the general classifications of the type of control, such as hydraulic, pneumatic or electronic. The specifications must also define whether the instruments are to be locally mounted at the equipment under control, or whether the instrumentation is to be centrally located with remote control. The tendency in recent years has been very much in favor of centrally located instrumentation in order to reduce to the minimum the manpower required to operate a plant.

e. *Electrical*—The electrical specifications must describe: the areas in which the equipment must be suitable for hazardous operations; whether the distribution system is to be above or below ground; electric control equipment such as starters to be located adjacent to or remote from the equipment being started; and the quality and capacity of the over-all installation.

f. *Mechanical Equipment*—The mechanical equipment specifications normally cover pumps, compressors and their drives. These specifications define the type of equipment to be used in the various services such as corrosive, non-corrosive, hazardous, non-hazardous, high temperature, low temperature; types of drives such as steam, electric, gas turbine, etc. Quality must be carefully specified as it has a marked effect on efficiency, price and durability.

g. *Special Equipment*—Under this category are usually specified those special pieces of equipment that can not be covered by the above general headings, such as packaged equipment or equipment completely designed, fabricated and erected under a subcontract. These specifications of necessity must be as carefully prepared as any other specification in order to obtain the quality and efficiency desired, as well as to specify capacity.

2. **Process Piping and Instrument Flow Diagrams** are developed from the process flow diagram and equipment schedules. They also incorporate information concerning the Specifications. Process P & I flow diagrams, in general show every piece of equipment, all piping and all instrumentation diagramatically. Each piece of equipment is marked with a number or symbol which identifies it with a schedule or specification. Each pipe line is identified with a number, size and specification symbol. It therefore diagramatically defines the plant and becomes one of the major tools used in preparing the detail designs.

3. **Utility Flow Diagrams** similar to the process P & I flow diagrams are prepared for utilities such as steam, water, air, fuel oil and fuel gas. These flow diagrams incorporate the same kind of information as described for the process P & I flow diagrams.

4. **Planning Studies** can be very important when it is realized that a large multi-million dollar plant may require several hundred thousand man-hours to develop a set of drawings. Even a small single process unit may require as much as 20,000 man-

hours of drafting. Therefore, careful planning must be given to the development of the job.

To accomplish this goal, a comparatively small number of men are divorced from the main design sections and take the basic information and plan the project. The first step is to prepare the process flow diagrams from equipment schedules and process sketches furnished by the process engineers. The next step is to develop the process P & I flow diagrams and utility flow diagrams in order to define the project diagramatically. With the process P & I flow diagrams, utility flow diagrams, process vessel sketches, schedules and specifications available, plot plans, and general arrangement drawings can be prepared. Usually it is necessary to prepare several studies of the plot plans and general arrangement drawings before a satisfactory arrangement can be developed. Upon completion of a satisfactory plot plan and general arrangement drawing, a block model of the plant is constructed and studied to determine if access to the major equipment is suitable for efficient construction and maintenance and the equipment has been arranged processwise in orderly sequence. When the model and the studies of the plot plant are satisfactory, a final plot plan drawing is prepared and issued "approved for construction"; thus fixing the arrangement of all major equipment.

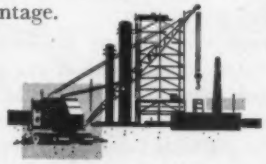
From this point all future studies are based on the fixed plot plant. Study drawings are prepared to develop the general arrangement of all structures, platforms and supports, all major runs of piping and the detail arrangement of piping at equipment. In developing these studies, sufficient detail work is performed to insure that the arrangements can be followed without interferences. As soon as these fundamental studies are completed, they are approved for drafting and sent to the main Drafting Room for the completion of detailed design.

5. **Purchasing and Bid Analysis.** Previous to purchasing, a requisition for the article to be purchased must be prepared. This requisition must include drawings and/or specifications defining quantity, quality, capacity or size. The more complete and accurate the requisition, the more complete and fixed the vendor's proposal.

In order to take advantage of the market, it is customary to send the inquiry to more than one vendor. By following this procedure, the best possible price and delivery can be obtained. Often the best price and best delivery are not furnished by the same vendor and it becomes necessary to weigh the advantage of each before selecting a vendor. To properly appraise the quotations, bid analyses are prepared which analyze the vendor's quotation from the standpoint of quality, capacity, price, efficiency, delivery and, often, flexibility. Each of these qualifications is carefully analyzed to determine which offering is the most advantageous to the job. In some instances, it is necessary to negotiate with the vendors to determine their best offering.

Detail Design must utilize special skills and training to best advantage and most large design rooms are divided into several sections, such as structural, tower and tank, piping and electrical. These sections limit their design work to their specialty. Each section must maintain constant contact and cooperation with the other sections in order that the work as a whole can be performed efficiently. Since the planning studies made in the Planning department have been thought out carefully, the detail designs can be carried out with a minimum of interference and delay.

Each section in the main drafting room must perform their work in strict accordance with the specifications. In the detail design the latest techniques are used and standards are followed to the greatest extent possible. Electronic computers are used wherever possible for calculating purposes. An effort is being made to program additional work for electronic computers in order to remove calculations of a repetitive nature from the duties of a designer so that he can use his full talents to best advantage.



PLANT CONSTRUCTION

Manpower required for construction has been discussed under Job Design and Job Schedules.

The control estimate for construction has been discussed under Estimating.

Tools required for construction vary a great deal, both as to kind and capacity, depending on the scope of the work. On a large job they range from small hand tools to large 250-ton guyed derricks. Careful study by experienced construction personnel is necessary to determine the optimum quantity, capacity and type of tool for each particular job. Too few tools result in the use of unnecessarily large labor forces—and too many tools result in idle time for tools and excessive tool rental cost.

The choice of large tools is particularly difficult. A large guyed derrick, based on its monthly rental, may appear on a rental basis to have an advantage over two large crawler cranes, until the cost of installation of the guyed derrick and its interference with other construction is taken into consideration.

Also the large guyed derrick may have an advantage and can be used efficiently, not only to handle heavy lifts, but due to its capacity and large radius of operation, can be used for many other purposes. All factors of this nature must be studied to arrive at proper tool selections.

Construction methods which can be followed to arrive at the same end result are usually many and varied. There may be wide divergences between methods as far as speed of construction and overall cost is concerned. The selection of the construction method to be used is usually determined by choosing two or more of the methods dictated by experience as being satisfactory, and making a careful estimate, taking into consideration all factors to determine which method is the better.

Labor relations must be good in order to perform construction work efficiently. In general, labor disputes arise from working conditions, wage rates and jurisdictional rulings.

Working conditions consist of safety rules, distance of work from parking areas, travel time brought about by the location of the work in relation to the nearest town, accommodations for changing clothes, sanitary provisions, hours for starting and stopping work, etc. Working conditions are based on local prac-

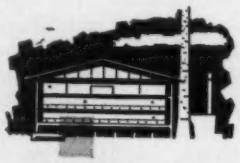
tice and, usually, can be satisfactorily worked out prior to the start of construction.

Wage rates are also based on local practice and are determined prior to start of construction. In general, wage rates are fixed for a certain period of time and, in some instances, for the length of the job. Automatic increases are sometimes provided to take place within a given period of time or under a defined set of conditions. The basic wage rates provide for work during the normal scheduled hours of work and are usually for a maximum of a forty-hour, five-day week. Formulas are provided for rates and/or hours of pay for work performed outside of the scheduled hours of work, and also to cover those instances when labor is called out by contractor, but, due to climatic or other conditions, it is impossible to work for all or part of the scheduled day.

Jurisdictional problems arise when one or more labor crafts claim work which, based on area practices or other reasons, should be performed by other crafts. In an endeavor to eliminate this kind of dispute, every effort is made prior to start of construction to obtain an agreement with the various labor representatives on the division of the work among the crafts.

The labor relations problems are the responsibility of the construction superintendent and, as far as possible, are resolved by him. When these problems can not be resolved on a local basis, it becomes necessary to use the home office of the contractor and, in some cases such as jurisdictional disputes, to have the national labor leaders make the devision as to which labor craft is to perform the work.

Hydrostatic testing is conducted as the construction work progresses to establish that the equipment has been properly manufactured and field assembled to contain the materials being processed. The medium used in hydrostatic or pressure tests is usually water; but in some instances, due to the demands of the process or materials of construction, other mediums, such as oil, air, ammonia, sulfur dioxide, etc., are used. The equipment is tested in accordance with the governing code or specification. The hydrostatic or pressure testing is done with great care; the tests are recorded, giving descriptions of equipment tested, medium used in testing, pressure, temperature, length of test in time, date, and results. The tests are repeated until satisfactory, and the satisfactory test is usually witnessed by a representative of the owner.



PLANT OPERATION

Operating Instructions and Operators. In order to insure that the plant will be operated in accordance with the process design, detailed operating instructions are prepared. The operating instructions are the joint effort of the process engineer, project engineer, and operator. The operating instructions are frequently reviewed by the customer and are used by him to instruct his operating personnel so that they will have a complete understanding of the plant prior to start-up.

Every effort is made to complete the operating instructions well in advance of the completion of construction. General practice is to assign a chief operator to each job several months prior to the completion of construction in order that he can witness all hydrostatic tests and become completely familiar with the physical layout of the plant. Assigning the chief operator prior to completion of construction also furnishes an opportunity for the plant to be thoroughly checked from an operating standpoint, and obvious deficiencies corrected without delaying construction completion.

Several weeks before construction completion, the balance of the operators are assigned in order that they too can become completely familiar with the physical layout of the plant. Usually, sufficient operators are assigned so that each operating unit is covered during each shift, with the chief operator being on the day shift. The chief operator is responsible for the coordination and operation of the complete plant.

Run-In and Tightness Test. After completion of construction and hydorstatic testing, the mechanical equipment is "run in". This is usually done where possible by filling the system with water and running the pumps for a period of from twenty-four hours to several days. During this period, control devices are set to maintain design conditions as nearly as possible and, of course, alignment of all equipment and performance of bearings are carefully checked. The compressors are "run in" on air, care being taken not to overload the drivers, nor to exceed temperature and pressure limitations. Control devices are set, alignment is checked, and bearings are adjusted. Should there be inadequacies in the support of piping, they are usually brought to light during these "run-in" tests, at which time steps are taken for their correction. Even though the system has previously been accepted from a hydrostatic test standpoint, the starting of mechanical equipment usually results in some leakage and requires tightening to make the system satisfactory.

Mechanical Adequacy. After operating the system on water and air or other liquids or gases has proved satisfactory, the system is drained and flushed out or dried out; after which the material to be processed is introduced. Temperatures, pressures and flow rates are gradually increased to approach those provided for in the design. As pressures and temperatures are raised, due to the fact that the processed material will normally have viscosities and gravities lower than the water and air used for testing, additional leakage will develop. Likewise, the mechanical deficiencies will be brought to light as a result of the elevated temperatures and pressures. These deficiencies are of course corrected as they develop.

Preliminary Operation. Once the mechanical adequacy of the system has been proved, design charge stocks are charged to the unit and design conditions of flow, pressure and temperature are established. Here again it is not unusual for additional deficiencies to develop, due to the more severe conditions to which the equipment is being subjected, and these

deficiencies must be corrected. During this preliminary operation, sufficient data are collected to determine that, from a charge and product capacity standpoint, the system appears to be capable of meeting the design conditions. Should this not be true, the deficiencies are corrected.

Test Run and Acceptance Test. As soon as the preliminary operation has progressed to the point where there is reasonable assurance that design conditions can be met, a formal notice is presented to the owner stating that the contractor is ready for a test run and acceptance test. The period during which the test run is to be conducted is usually a condition of the contract. During the test run the operation is maintained as nearly as possible to that required in the design basis by charging design stock, producing design products and maintaining all other design conditions such as capacity, pressures, temperatures, etc., constant. If the test run does not meet the design conditions, the deficiencies are corrected and the test run is repeated. As soon as the Acceptance test run meets design conditions for the required period, the unit is accepted by the owner.

'AS-BUILT' DATA BOOKS

At the completion of the project, data books are prepared incorporating basis of design, flow diagrams, plot plans, specifications, equipment schedules and data sheets, manufacturer's instructions, index of purchase orders, and an index of manufacturer's certified prints. The data furnished are quite voluminous and are of material value to the owner, particularly in reference to maintenance and operation of the plant.

ACCOUNTING

Considering the variety of types of contracts involving many different definitions of costs, overhead and profit encountered in contracting work, it is obvious that fulfilling the requirements of a contract requires complete and accurate accounting. Checklists defining costs, overhead and profit are made a part of the contract. Irrefutable accounting evidence must be accumulated throughout the life of the project to show that all costs have been charged to the proper categories. Return costs which, in many cases, form the very basis of new estimates again point up the necessity for complete and accurate accounting.

A code of accounts has been developed to accomplish the necessary accounting which is sufficiently complete to allow each and every operation to be classified and costs accumulated.

Each office employe working on a project is required to keep a time sheet and to charge against the projects his actual time. In this manner costs are accumulated for engineering, purchasing, drafting, accounting, etc. for each job. Each purchase order is classified as to project and code of accounts, allowing all material and equipment cost to be properly accumulated.

In the field, supervisory and salaried personnel are required to keep time sheets. Hourly personnel are classified by trade and their time is charged against the operation on which they work on the basis of daily time distribution reports prepared by the foreman; again in accordance with the code of accounts. With data available from these time distribution sheets, it is possible to determine the labor costs of each operation such as pouring concrete and erecting piping, towers, pumps and other equipment.

All construction tool and equipment costs are accumulated and charged against the proper accounts. Cards are maintained giving information as to when the tool or piece of equipment arrived at the jobsite, the rental rate, how and when it was used and when it left the jobsite. In this manner, tool and equipment costs can be determined for each operation.

At frequent intervals during the life of a project, all costs to date are accumulated and estimates are made by account of further costs required for completion. The sum of these two costs is then compared with the control estimate to determine the standing of the job from a profit or loss standpoint. Accurate and current accounting data must be available in order for this control to be effective.

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The men who took part in this program

Parker

MacGregor

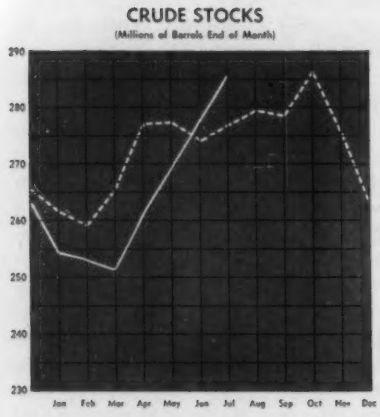
Bridier

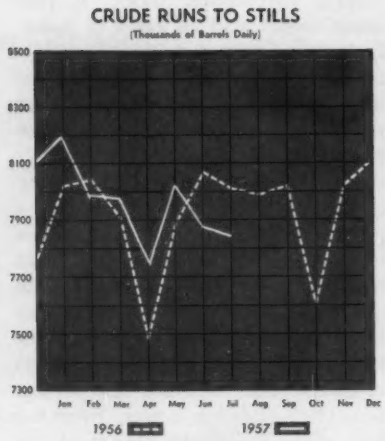
Albert

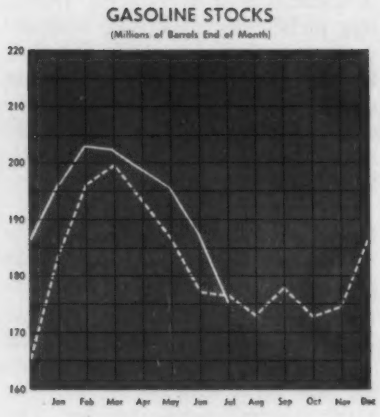
Florence

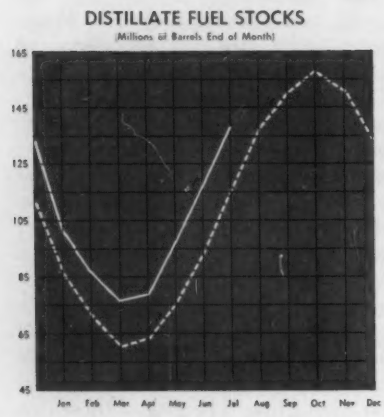
This industry team of Lummus Company engineers recently conducted a one-day school—"Industry Teaches the Teacher," to explain the function of engineer-contractors to local college chemical engineering professors. The material in this article formed the basis for the school. Enthusiastically received by the educators, PETROLEUM REFINER's editors felt this information would be of invaluable help to our readers.

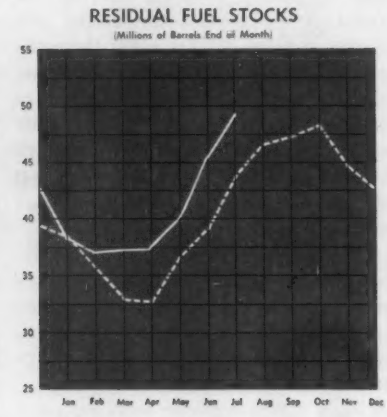
Under the direction of J. S. Parker, Jr., general manager, Engineering department, the following Lummus Company personnel conducted the school: (left to right) Don W. MacGregor, sales engineer; R. S. Bridier, manager, Coordinating, Construction, Estimating and Operation department; C. P. Albert, manager, Engineering department; and G. C. Florence, manager, Accounting department.

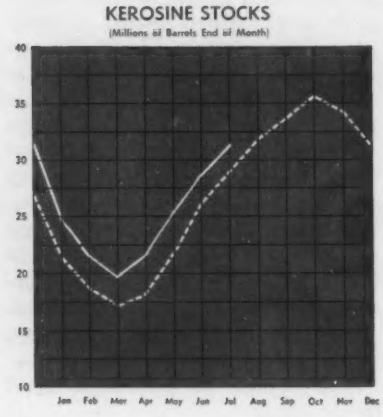












Taking Stock

Cecil W. Smith
Economics Editor

- **Gasoline stocks below 1956 level**
- **Distillate fuels 22 million ahead**
- **Crude imports reach new peak**

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1955:													
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	279	36,361	1,621	143,248	1,061	46,267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	299	18,227	1,713	63,571	1,130	32,740	315	1,305
May	7,064	7,896	277,497	3,859	186,673	292	21,883	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	290	26,111	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	296	28,990	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	313	31,826	1,839	137,905	1,091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	329	33,588	1,845	150,411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	356	35,667	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	384	34,329	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	379	31,420	1,981	133,981	1,288	44,491	873	1,471
1957:													
January	7,480	8,274	256,669	3,991	197,702	367	24,019	2,118	100,572	1,322	38,403	805	1,425
February	7,682	8,088	256,344	3,864	205,270	353	21,013	2,035	85,105	1,270	31,201	780	1,430
March	7,717	8,047	254,911	3,826	206,716	332	20,223	1,861	76,245	1,205	37,371	836	1,464
April	7,541	7,740	265,796	3,770	201,407	284	21,512	1,764	78,743	1,132	37,429	906	1,512
May	7,442	7,992	275,963	3,900	194,770	272	25,545	1,789	98,135	1,103	41,125	1,042	1,558
June	7,231	7,876	277,532	3,898	187,407	262	28,377	1,743	116,966	1,129	45,342	1,173	1,605
July	6,907	7,850	285,656	3,812	195,952	262	31,343	1,749	137,600	1,095	49,082	1,188	1,556
Week Ended:													
8-16-57	6,837	7,969	286,618	3,894	172,136	250	33,021	1,775	146,703	1,120	50,923	1,236	1,610
8-17-56	7,122	7,899	277,065	3,910	176,202	329	30,717	1,812	128,934	1,128	44,996	1,007	1,352

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

Now—Petrochemicals from Resid

This new moving bed catalytic cracking process produces an olefin-rich gas which can be used directly for petrochemical manufacture.

Shigeru Tsutsumi
Osaka University
Osaka, Japan

THE TSUTSUMI PROCESS for the production of an olefin rich cracked gas from oil consists of the following three parts:

1. Complete gasification of raw oil (EP 660 F.) to produce a cracked gas which contains as much gaseous olefinic hydrocarbons as possible.

2. Without separating propylene from ethylene, the cracked gases are used for synthesis, in which propylene and ethylene are reacted simultaneously.

3. Pure ethylene is produced by selectively removing the propylene by alkylation and subsequently separating the ethylene-methane-hydrogen mixture.

The cracked gases obtained have been used successfully to make acetylene, aromatic hydrocarbons, cumene, ethylbenzene, terephthalic acid, and p-cresol. Two semi-commercial units are in operation as well as a large scale moving bed pilot unit.

Production of Cracked Gases. A pilot unit (using 0.79 gallon of oil per hour) was started in January, 1954 for the production of cracked gases. Raw oils, kerosine (EP 550 F.) and light oil (EP 660 F.) were used and cracked at 1600 F. under reduced pressure of 200-300 mm Hg in the presence of special catalysts. Composition of the gas produced was:

Propylene + Butylene	15-20%
Ethylene	30-35%
Hydrogen	20-25%
Methane (small amount of ethane	30-35%

Gas production was 24.7-28.2 cubic feet from 0.26 gallons of oil and the olefins content was 50-55 percent. The production of olefin rich gases is the most important part of the Tsutsumi process.

Production of Acetylene. Looking at the present status of Japan, proper raw materials may be kerosine or light oils and also a 660 F. crude oil cut.

The cracked gas produced by the method described above was successfully converted to acetylene with a 65 percent by weight over-all yield. The petroleum acetylene obtained gave the same yield of vinyl acetate as carbide acetylene.

Production of Aromatic Hydrocarbons. A pilot plant for the production of aromatic hydrocarbons was started in April, 1954. Aromatic hydrocarbons composed of 50-60 percent benzene, 10 percent toluene and 7-8 percent xylene were obtained by the catalytic aromatization of the cracked gases described above at 1380 F. and under the pressure of 28 psi.

Raw oil required to produce 1000 pounds of aromatic mixture is estimated from experimental data as follows:

Raw oil	Products
34.2 gallons	Benzene 600 lbs.
	Toluene 200 lbs.
	Xylene 150 lbs.
	EP 390F 50 lbs.
	Total 1,000 lbs.

Production of Cumene and Ethyl Benzene. The cracked gas (propylene, ethylene, hydrogen and methane) was alkylated with benzene in the presence of a $CuO\text{-}H_3PO_4$ = 1:1.5 (mole ratio) catalyst at 520-570 F. and an initial gas pressure of 560 psi.

The ethylation of benzene was accelerated in the presence of propylene with 100 percent conversion of propylene and 96.4 percent conversion of ethylene. Yields of 81.7 percent ethylbenzene and 100 percent cumene were obtained.

The ethylbenzene obtained was dehydrogenated at 1110 F. under reduced pressure in the presence of a

Petrochemicals from Resid . . .

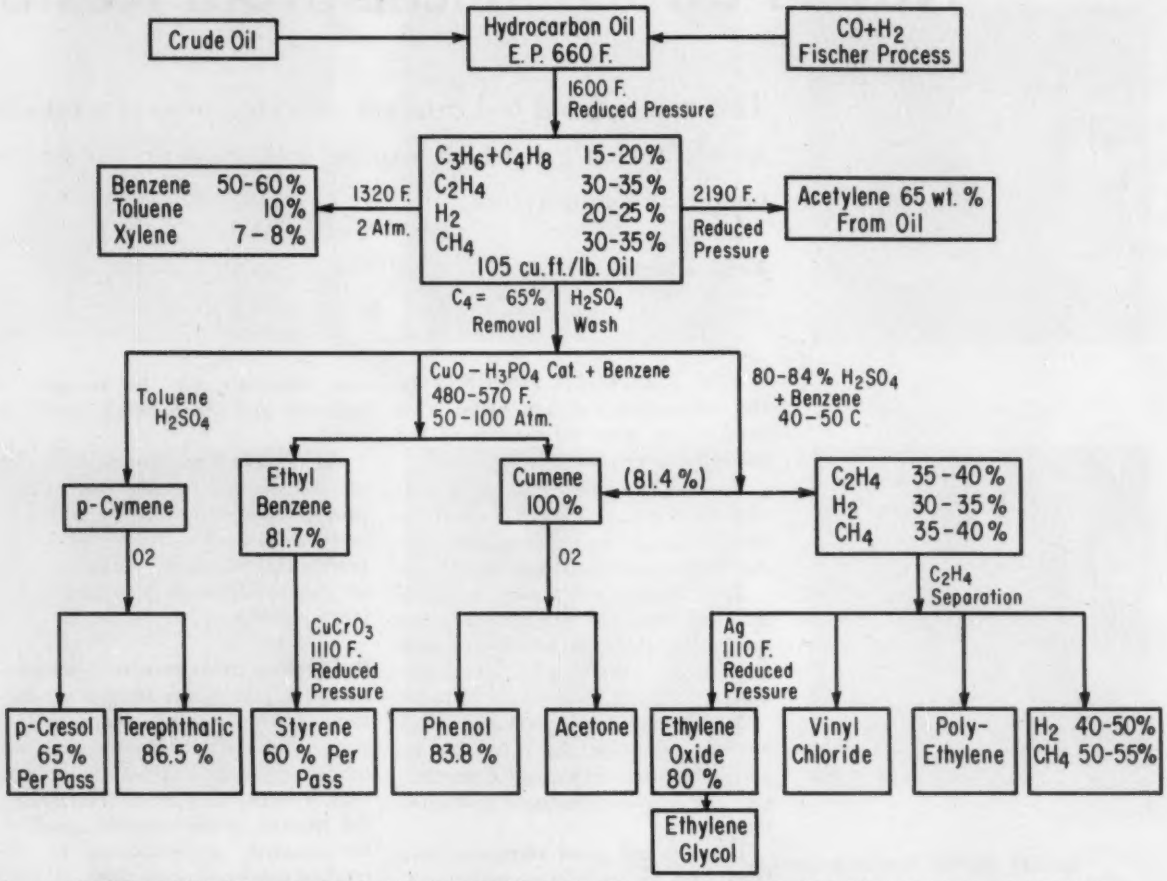


FIGURE 1—Block diagram and material balance of the Tsutsumi process for petrochemials. (Converted from metric units.)

copper chromite catalyst and styrene yields of 60 percent per pass were obtained.

Cumene was oxidized at 185-195 F. by oxygen in producing 83.8 percent yield of phenol.

Production of Cumene and Separation of Ethylene. Cracked gases were bubbled out through a mixture of benzene and 84 percent sulfuric acid at 110 F., and 81.6 percent yield of cumene was obtained.

The propylene in cracked gas reacted selectively with benzene, and the exit gas was a mixture of 35-40 percent ethylene, 30-35 percent hydrogen and 35-40 percent methane.

The separation of ethylene from such an exit gas is carried out by the use of a proper extraction method.

The ethylene obtained was converted to ethylene oxide, polyethylene and vinyl chloride.

The production of ethylene oxide was carried out at 1100 F. under reduced pressure by the oxidation of ethylene with air in the presence of silver catalyst.

The content of silver in the catalyst is as little as 2 percent, although other catalysts contain about 30 percent silver.

The use of reduced pressure retarded the formation of carbon dioxide and increased the yield of ethylene oxide to 80 percent.

Synthesis of Terephtalic Acid and p-Cresol. The raw material selected was p-cymene produced by the selective reaction of propylene in the cracked gases with toluene.

p-Cymene was oxidized with oxygen at atmospheric pressure at 150 F., yielding 65 percent of p-cresol.

p-Cymene was oxidized with oxygen under 300-600 psi at 320 F., 62 percent of this compound was oxidized and the ultimate yield of terephthalic acid was 86.5 percent.

The synthesis of hydroquinone from diisopropyl benzene is now being carried out as a part of this over-all process. (See Figure 1.)

Fluid Cracking Process. At present, two semi-industrial plants using this process have been constructed, i.e., Kurashiki rayon plant for the production of acetylene from petroleum with a daily capacity of 35,310 cubic feet and Yawata iron plant for the production of ethylbenzene and cumene simultaneously from cracked gas.

A third pilot plant at the laboratory differs somewhat from the above two plants.

This pilot plant is of moving bed type, about 73 feet in height and the whole system is under reduced pressure. The main parts are: a preheater, reactor, cooler, elevator, and hopper. Catalyst of 0.15-inch size is circulated at 441 pounds per hour velocity. The catalyst is preheated to 2010-2190 F. and flows down to the reactor where the temperature is 1380-1650 F.

Approximately equal volumes of oil

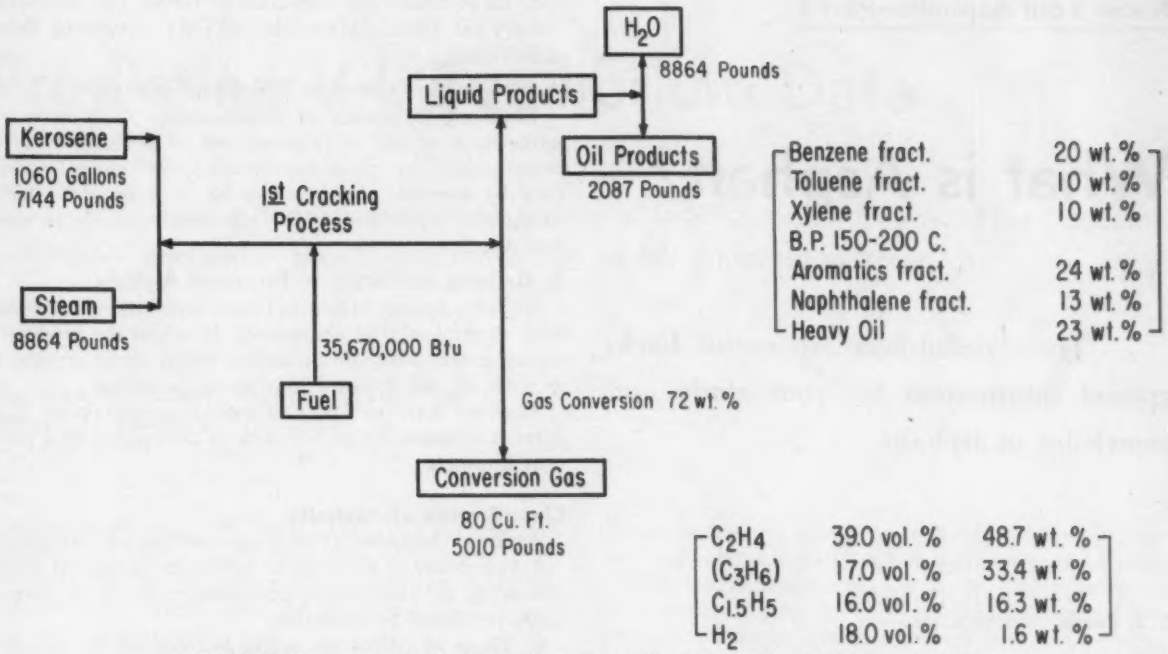


FIGURE 2—Typical results from the Tsutsumi vacuum cracking process. (Converted from metric units.)

and water are preheated to 750-840 F. and introduced to the reactor with complete cracking. The oil produced is mostly aromatics. The mixing between the flue gas in the pebble preheater and the cracked gas in the reactor is successfully minimized by controlling the pressure difference between the two parts by the use of a differential pressure controller.

The typical results are shown in Figure 2.

The weight percent of products for kerosine (B.P. 310-510 F.) used is shown in Table 1.

TABLE 1—Products of Kerosine Cracking

Gaseous products		
C_2H_4	34.2 percent	
C_3H_6	23.4 percent	
$C_{1.5}H_5$	11.4 percent	(containing small amount of ethane)
H_2	1.1 percent	
Total	70.1 percent	
Liquid products		
Benzene	5.8 percent	
Toluene	2.9 percent	
Xylene	2.9 percent	
B.p. 300-390F. aromatics	7.0 percent	
Naphthalene	3.8 percent	
Heavy Oil	6.8 percent	
Total	29.2 percent	

About the Author

SHIGERU TSUTSUMI is a professor at Osaka University, Osaka, Japan. In March, 1932 he graduated from Tokyo Imperial University, and in April, 1940, received his Ph.D. degree. In 1935 Tsutsumi was an engineer in the Fuel Research Institute, then in 1940, he became a professor at Osaka University and a member of the Institute of Scientific and Industrial Research. In 1949 he was placed in charge of applied chemistry on the faculty of engineering at Osaka University.

As shown in Table 1, the yield of olefins is as high as 57.6 percent and the liquid products are nearly pure aromatics.

Although the idea of Catarole process seems to be similar to this process, its temperature is as low as 1290-1380 F. Thus, the yield of olefins is comparatively small, 11.6 percent of ethylene and 10.2 percent of propylene, and the amount of aromatics (BTX) is nearly the same as for this process. Two other processes are reported to yield olefins in an order of 35 percent and 27 percent respectively.

As mentioned above, this process is characterized by the high yield of olefins and by the nearly pure aromatic liquid products with no gasoline production.

As charge stock raw oils, gasoline, naphtha and heavy oils can be used, and when lighter oils are used, the yield of olefins is increased by about 5 percent.

ACKNOWLEDGMENT

The author is indebted to the Ministry of Education of the Japanese government for the financial assistance received and also to Chiyoda Chemical Engineering & Construction Company of Tokyo for financial assistance and the construction and operation of the laboratory plant. Akiyoshi Tamaki, managing director and chief engineer of Chiyoda Chemical Engineering & Construction Company, sponsored the industrial development of the Tsutsumi Process.

Know Your Asphalts—Part 1

What is Asphalt?

These definitions are useful background information for your study and knowledge of asphalts.

E. J. Barth, Asphalt Consultant
New York City

ASPHALT IS a mixture of many hydrocarbons of high boiling-point range; its main characteristic is that of stickiness." The word is from the Greek, "Asfaltos or asfalton," meaning to make secure or fast, or something which is secure, tight or cemented together. It is the oldest engineering material known to man. The earliest or Biblical references of location and uses relate to Noah, who in his thriving asphalt waterproofing business in Mesopotamia, used asphalt to waterproof the Ark.

Innumerable seepages abound to this day along the Tigris and Euphrates rivers in Iraq; these were the sources of asphalt supply for the builders of boats and towers dotting the plains, and which were called ziggurates; the tallest of these called the Tower of Babel (Gen. X: 1, 3) was constructed with asphalt used to cement the stone blocks. Asphalt was used by the Babylonians for embalming purposes (2568 B.C.), and from the Persian word "mumiya," signifying asphalt, comes the English word mummy.

Asphalt is found widely scattered throughout the world, both in pure forms, and in forms where the hydrocarbon material is contaminated with colloidal clays, silts, sand or other inorganic matter. It occurs most commonly in heavy crude oils, which are the usual sources of asphalt. The largest asphalt deposits, or better heavy petroleum of asphaltic nature occurs in the form of "tar sands" in the Lake Athabasca region of northern Canada; these deposits of available and reserve oil included are the largest in the world, larger in extent and tonnage than the total Middle East oil fields combined.

The word "bitumen" (Latin: pix, or pitch, and tumen or swelling or swelling pitch, such as seen in seepages) is often confused with and used interchangeably with the word asphalt; the former connotes the straight hydrocarbon mixture free from all impurities or adventitious matter such as colloidal clay, ash, silts, and sands, etc. To eliminate the confusion of terms, the American Society for Testing Materials (ASTM) established these definitions:

A. **Relating in General to Bituminous Materials**

Bitumens: Materials of hydrocarbons of natural or pyrogenous origin, or combinations of both, frequently accompanied by their non-metallic derivatives, which may be gaseous, liquid, semi-solid or solid and which mixture of hydrocarbons are completely soluble in carbon disulfide.

B. **Relating specifically to Petroleum Asphalts**

Asphalt: A dark brown to black cementitious material, solid or semi-solid in consistency, in which the predominating constituents are bitumens, which occur in nature as such, or are obtained by refining petroleum.

Thus we refer to Trinidad asphalt as containing 56.1 percent bitumen, or of Gilsonite as containing 99.4 percent bitumen.

Classification of Asphalts

Artificial Asphalts: (Practically 100 percent bitumen)

1. Petroleum or oil asphalts: physically separated from petroleum by distillation, percipitation, etc., or chemically produced by oxidation.

2. Those of petroleum origin but formed by complicated condensation reaction during the cracking of petroleum or similar splitting reactions.

Natural Asphalts:

1. Containing impurities, e.g., inorganic matter insoluble in carbon disulfide.

Trinidad, refined—53-56 percent bitumen.
Bermudez, refined (Venezula)—Approximately 90-43 bitumen.
Cuban (Benjucal, Marial)—80-90 percent bitumen.
Natural rock asphalts—5-30 percent bitumen impregnated in sand or limestone.

2. Asphaltities—containing no impurities or insoluble inorganic matter.

a. Solid Bitumens:
Gilsonite (Uintaite)—90-99 percent bitumen, 270-400 F melting point.
Grahamite—40-100 percent bitumen, 370-650 F. melting point.
Glance Pitch, Barbados Manjak, (Cuban, Utah, Syrian)—about 80-95 percent bitumen, 270-370 melting point.

b. Asphaltic Pyrobitumens (Weathered Bitumens):
Wurtzilite—5-10 percent bitumen; Intumesces.
Elaterite—Only slightly soluble; Intumesces.
Albertite—3-7 percent bitumen; Intumesces.
Impsonite—Insoluble; Intumesces.

The pyrobitumens upon further weathering merge by way of Impsonite into the non-asphaltic pyrobitumens, which are the lignites, montan waxes and coals.

Coal-Tar Products: Coal-tars, water-gas-tars and their pitches are artificial bitumens consisting of highly condensed aromatics, derived from high and low temperature destructive distillation of various coals, or from water-gas operations; contain variable though high, percentages of bitumen together with insoluble matter called "free carbon."

Part 2 will appear in an early issue.

Predicting V-L Equilibrium Data . . .

. . . for temperatures and pressures below critical points. This "activity coefficient" method is good for binaries and multicomponent systems.

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THIS METHOD OF TREATING experimental vapor-liquid equilibrium data has these advantages:

- It is simple in form, containing no arbitrary constants and only two mixture rules (the pseudocritical temperature and pressure).
- Its is completely analytical in form, using temperature and pressure as independent variables. It can be easily adapted to an electronic computer program.
- It facilitates the estimation of related p-v-t and thermodynamic properties for process calculations.

Previous Approaches. In the treatment of experimental data there are three principal approaches that have been used with success. The first and most widely used approach involves the calculation of the activity coefficient defined by equation (1),

$$\gamma = \frac{\bar{f}}{zf} \qquad (1)$$

which can be smoothed and compared quite easily.

The principal difficulty encountered in calculating the activity coefficient of a component in a mixture lies in the estimation of the fugacity. This is usually done by computing the fugacity of a component in a vapor mixture for which adequate equations of state are available and making use of the thermodynamic principle that at equilibrium the fugacities of a component in the liquid and vapor phases are equal. The fugacities of the pure component vapor and liquid must also be estimated, but this is a relatively straight forward problem. Experimentally determined phase compositions are required for these calculations and to be sure that experimental error has not entered into the calculated value for the activity coefficients they are generally tested by some form of the Gibbs-Duhem equation,

$$x_1 \left(\frac{d \ln \gamma_1}{dx_1}\right)_{P,T} = x_2 \left(\frac{d \ln \gamma_2}{dx_2}\right)_{P,T} \qquad (2)$$

about which more will be said later.

Many authors have used this technique and the reader is referred to an excellent survey article on this subject by Redlich, Kister and Turnquist.[12]

A second approach to the treatment of experimental vapor-liquid equilibrium data which is used less extensively involves the development of an equation of state for liquid mixtures as well as for vapor mixtures. Mixture rules, or the combination of constants for pure components in equations of state for mixtures, are selected and adjusted until the fugacities calculated from the equation of state are consistent with experimental vapor-liquid equilibrium data. Benedict, Webb, Rubin, and Friend[1] have done extensive work using this approach.

A third approach is purely empirical in nature. It has been found that a parameter called the convergence pressure correlates vapor-liquid equilibrium data quite well. The reader is referred to the work of Lenoir and White[7] as an example of this type of study. The convergence pressure method gives superior results in reproducing experimental data and, therefore, is an excellent method for correlating data. However, it does not offer an opportunity for testing experimental data for thermodynamic consistency.

All of these methods have their strong and weak points. The principal weaknesses of each are listed below.

Activity Coefficient Method. The estimation of fugacities is the principal drawback in this method. At the temperature and pressure under which a mixture might exist some components do not naturally exist in the pure state as liquids and some do not exist as vapors. Hence the pure component fugacity that needs to be estimated is the property of a hypothetical state and its value is obtained from an extrapolation of the fugacities of real states. The more extensive the extrapolation the less meaningful the value of the computed activity coefficient.

Equation of State Method. The principal disadvantage of this method is the tedium of long trial and error techniques necessary to develop appropriate equations of state and mixture rules. While high speed electronic computers are a partial answer to this weakness, the complexity of

PART 1

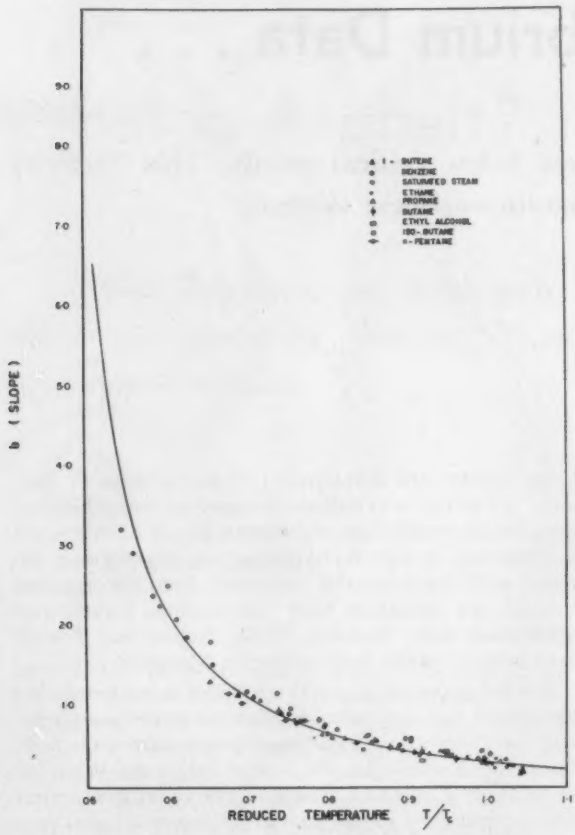

FIGURE 1—Slope of fugacity coefficient isotherm: It gives the value for b in fugacity equation.

the calculations involved are discouraging to most process engineers.

Convergence Pressure Method. This method involves the use of many charts or tables and offers some difficulty in interpolation. However, the results obtained are so close in agreement with experimental data that the use of many charts and tables seems justified. As yet convergence pressure techniques are not readily adaptable to high speed electronic computers. There is much work in this direction at the present time.

Proposed Method. The method of treating experimental data which is presented here is based on the "activity coefficient approach" and has all its disadvantages. It has been used in this work because it lends itself readily to thermodynamic analysis. It is simple in form, and can be easily adapted to high speed electronic computers.

The equations employed by Redlich, Kister and Turnquist[12] and Benedict, Webb, Rubin, and Friend[1] use temperature and density as independent variables. Since temperature and pressure are the independent variables that the process engineer deals with it would be more advantageous to employ them in equations of state. In general this is impossible. However, if for the purpose of a vapor-liquid equilibrium study, attention is confined to pressures below the critical pressure then the use of such equations are not only possible but also quite simple.

The fugacity coefficients of ethane, propane, n-butane isobutane, n-pentane,[16] l-butene,[17] benzene,[10] ethyl alcohol[13] and water[8] in the vapor phase were studied and were found to be satisfactorily correlated by the equation

$$\frac{f^v}{P} = 1 - b\,Pr \tag{3}$$

$$\text{where } b = \frac{0.1488}{(T_r - 0.34)^2} \tag{4}$$

Figure 1 is a plot of b versus T_r for all of the compounds mentioned above. Equations (3) and (4) are strictly valid in the region

$$0 \leq P_r \leq 0.8$$
$$0.6 < T_r < 1.2$$

All other p-v-t and thermodynamic properties can be derived from equation (3). Using the thermodynamic relationship,

$$\left(\frac{\partial \ln f^v/P}{\partial P_r}\right)_{T_r} = \frac{Z^v - 1}{P_r} \tag{5}$$

The following expression for the compressibility factor, ($Z^v = PV/RT$), is obtained.

$$Z^v = 1 - \frac{b\,P_r}{1 - b\,P_r} \tag{6}$$

Also, using another thermodynamic relationship,

$$\left(\frac{\partial \ln f^v/P}{\partial T_r}\right)_{P_r} = \frac{H^\circ - H^v}{R\,T\,T_r} \tag{7}$$

One obtains,

$$H^\circ - H^v = -\frac{RT\,T_r\,P_r}{1 - b\,P_r}\left(\frac{\partial b}{\partial T_r}\right)_{P_r} \tag{8}$$

where

$$\left(\frac{\partial b}{\partial T_r}\right)_{P_r} = \frac{-0.2976}{(T_r - 0.34)^3} \tag{9}$$

The validity of Equation (3) can be tested by comparing the compressibility factors computed from Equation (6) with those found in the literature. Lyderson, Greenkorn and Hougen[8] studied compressibility factors of many compounds reported in the literature. These authors found that a third parameter, the compressibility factor at the critical point, Z_c, was necessary to adequately correlate p-v-t properties as a function of reduced temperature and pressure. In Table 1, a comparison of compressibility factors computed by the use of Equation (6) with those reported by Lyderson, Greenkorn and Hougen[8] is presented. The values in the parentheses are those reported by Lyderson, Greenkorn and Hougen[8] for compounds whose critical compressibility factors are 0.25 and 0.29, respectively. The agreement is satisfactory in view of the absence of the third parameter in this work. The reason for excluding the third parameter in this work will be explained later.

Mixture Properties. To compute properties for mixtures it is necessary to select mixture rules to be used in conjunction with the reduced equation of state given above. For the purposes of this work, the mixture rules originally presented by Kay[5] have been selected and are given by Equations (10) and (11)

$$T_c' = \Sigma y_i T_{ci} \quad (10)$$

$$P_c' = \Sigma y_i P_{ci} \quad (11)$$

The quantities, T_c' and P_c', are known as the pseudocritical temperature and pseudocritical pressure. At the present time no mixture rules have been suggested or tested for a third parameter. It is for this reason that the third parameter was not used in the study of pure component fugacity coefficients.

Joffe[4] has presented an equation giving the fugacity of a compound in a mixture in the vapor state using reduced correlations and Kay's pseudocritical mixture rules. Equation (12) is the form of the fugacity equation presented by Joffe.[4]

$$\ln \frac{\bar{f}_i^V}{Py_i} = \ln \left(\frac{f^V}{P}\right)_{mix} + \left(\frac{H^\circ - H^V}{RT}\right)_{mix} \left(\frac{T_c' - T_{ci}}{T_c'}\right) + (Z^V - 1)_{mix} \left(\frac{P_c' - P_{ci}}{P_c'}\right) \quad (12)$$

Combining equations (3), (6), and (8) with (12) the following is obtained;

$$\ln \frac{\bar{f}_i^V}{Py_i} = \ln (1 - b'Pr') - \frac{Tr'Pr'}{1 - b'Pr'} \left(\frac{\partial b'}{\partial Tr'}\right)_{Pr'} \left(\frac{T_c' - T_{ci}}{T_c'}\right) - \frac{bPr'}{1 - b'Pr'} \left(\frac{P_c' - P_{ci}}{P_c'}\right) \quad (13)$$

Liquid Phase Equations. The fugacity of a pure liquid is equal to the fugacity of the pure vapor at the equilibrium pressure. Therefore, at its vapor pressure the fugacity coefficient of a pure liquid is given by;

$$\frac{f^\square}{p^\square} = (1 - bPr^\square) \quad (14)$$

The fugacity of a liquid at any other pressure can be computed by means of the thermodynamic relationship,

$$\ln \frac{f^L}{f^\square} = \int_{Pr^\square}^{Pr} \frac{Z^L}{Pr}\, dPr \quad (15)$$

As a first order approximation the liquid compressibility factor can be given by

$$Z^L = 0.15\ Pr \quad (16)$$

and equation (15), then becomes

$$\ln f^L = \ln f^\square + 0.15\ (Pr - Pr^\square) \quad (17)$$

For most vapor-liquid equilibrium problems the pressure correction term is small and Equation (17) is sufficiently accurate for first order approximations.

Rewriting Equation (1), the definition of activity coefficient, in logarithmic form,

$$\ln \gamma_i^L = \ln \bar{f}_i^L - \ln x_i - \ln f_i^L \quad (18)$$

and noting that at equilibrium,

$$\bar{f}_i^L = \bar{f}_i^V \quad (19)$$

equation (20) is obtained as a combination of (17), (18), (14) and (19)

$$\ln \gamma_i^L = \ln \frac{\bar{f}_i^V}{Py_i} + \ln \frac{y_i}{x_i} + \ln \frac{p}{p^\square} - \ln (1 - b_i Pr_i^\square) - 0.15\ (Pr_i - Pr_i^\square) \quad (20)$$

The first term on the right hand side of Equation (20) is given by Equation (13). The activity coefficient, therefore, can be computed directly from an experimental vapor-liquid equilibrium distribution ratio for any temperature and pressure assuming the vapor pressure is a known function of temperature.

Thermodynamic Consistency Test. The Gibbs-Duhem equation 2 can be rearranged to the following form

$$\frac{d \ln \gamma_2^L}{d\,(1 - x_1)^2} = \frac{d \ln \gamma_2^L}{d\,(1 - x_2)^2} \quad (21)$$

In Figure 2 are plotted the logarithms of activity coefficients of each component in the systems

1. ethane-ethylene (3)
2. ethane-propylene (9)
3. propane-propylene (2), (11)
4. propane-n-pentane (15)
5. 1-butene-n-butane (14)

versus the square of the mol fraction of the other component in the same system. It is immediately obvious that if the data points of Figure 2 are to satisfy Equation (21), then the only logical curves to draw through the points are straight lines. In other words the activity coefficients for the compounds in all the systems presented in Figure 2 follow the simple relationship,

$$\ln \gamma_i^L = B\ (1 - x_i)^2 \quad (22)$$

where B is a function of temperature and the compounds composing the binary.

Figure 2 does not only illustrate the satisfactory use of the equations developed above but it also affords an excellent opportunity to observe internal precision and consistency. Since no charts or tables had to be read to transform experimental data, as reported in the literature, into activity coefficients the scatter of the points are due entirely to experimental or smoothing uncertainties. It should be pointed out that all of the data with the exception of the ethane-ethylene system[3] were previously smoothed in some manner by the investigators who made the measurements. It would be more illuminating to observe raw data subjected to this type of analysis.

Temperature Dependence. These hydrocarbons follow the behavior of a class of binaries which can be described by the following relationships:

$$\ln \gamma_i^L = \frac{\omega}{RT} (1 - x_i)^2 \quad (23)$$

where

$$\omega = \omega^\circ + rT \quad (24)$$

Since

$$\left(\frac{\partial \ln \gamma_i^L}{\partial T}\right)_{P,x} = \frac{H^L - \bar{H}_i^L}{RT^2} \quad (25)$$

then

$$\frac{H^L - \bar{H}_i^L}{RT^2} = (1 - x_i)^2 \left[-\frac{\omega}{RT^2} + \frac{1}{RT} \frac{\partial \omega}{\partial T}\right] \quad (26)$$

or

$$H^L - H_i^L = -\omega^\circ (1 - x_i)^2 \quad (27)$$

The heat of mixing of a binary solution is defined by equation (28)

$$\Delta H \text{ mixing} = x_1 \bar{H}_1^L + x_2 \bar{H}_2^L - x_1 H_1^L - x_2 H_2^L \quad (28)$$

or

$$\Delta H \text{ mixing} = x_1 (H_1^L - \overline{H}_1^L) - x_2 (H_2^L - \overline{H}_2^L) \quad (29)$$

which when combined with equation (27) gives

$$\Delta H \text{ mixing} = \omega^\circ x_1 x_2 \quad (30)$$

Therefore, knowing the temperature dependence of ω for each binary is equivalent to knowing its heat of mixing. The values of ω° in Equation (30) for each system plotted in Figure 2 are as follows: ethylene-ethane, $\omega^\circ = 350$ BTU/lb-mole; propylene-propane, $\omega^\circ = 176$ BTU/lb-mole; n-butane —1-butene, $\omega^\circ = 114$ BTU/lb-mol. There is insufficient information on the system propane-n-pentane to determine ω° and for the system propane-propylene the data available lie in that region of temperature where the simple relationship given by Equation (24) does not.

It is not recommended that the numbers given above be accepted as the true heats of mixing but they will suffice in the absence of calorimetric data. When good thermal data are available it is much better to establish the value of ω° with the experimental heats of mixing and to compute the temperature coefficient of ω, r, from the vapor-liquid equilibrium data.

Further Improvement. The method can be further improved or refined and extended in applicability. For example, the fugacity coefficient Equation (3) can be improved by adding a quadratic term and introducing a

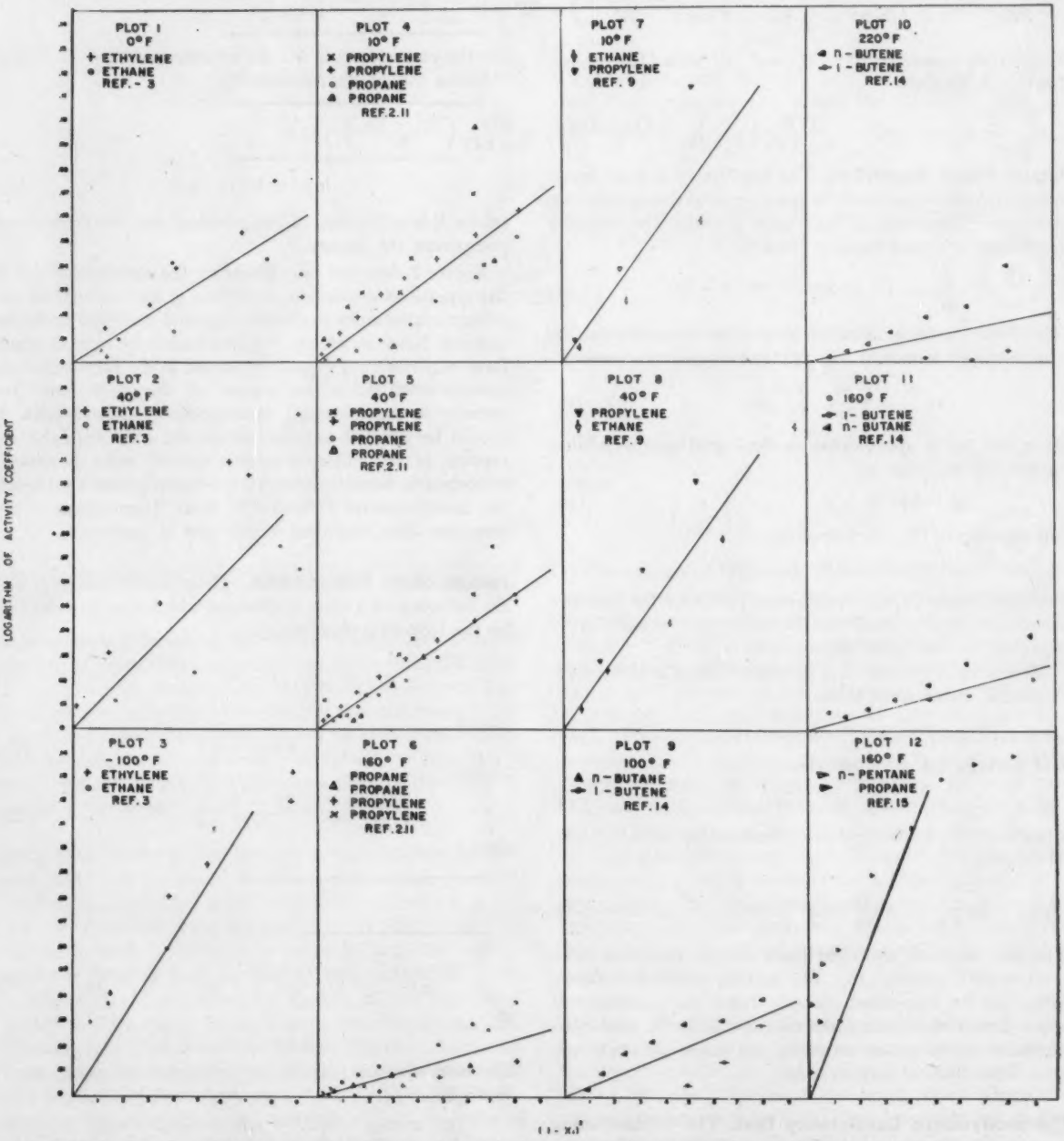

FIGURE 2—Activity coefficients of various binaries: A straight line through the data satisfies the thermodynamic consistency test.

third parameter. However, this will require precise p-v-t data in the low pressure region. In addition to employing a third parameter a satisfactory mixture rule for this parameter must be developed and Equation (13) expanded accordingly. Finally the correlation of activity coefficient with composition can be expanded from Equation (22) to the general form proposed by Redlich, Kister and Turnquist.[12] To justify such refined treatment the primary experimental vapor-liquid equilibrium data will have to be obtained with even greater accuracy than it has been in the past and analyzed in raw forms.

The second part of this series will be a discussion of multicomponent mixtures.

TABLE 1—Compressibility Factors Calculated from Equation (6)

T_r	0.60	0.70	0.80	0.90	1.00	1.10
P_r 0.01	0.978 (0.987-0.990)	0.988 (0.989-0.993)	0.993 (0.991-0.994)	0.995 (0.993-0.995)	0.996 (0.945-0.996)	0.997 (0.996-0.997)
0.1			0.924 (0.912-0.925)	0.950 (0.940-0.950)	0.965 (0.963-0.969)	0.974 (0.976-0.979)
0.3				0.834 (0.822-0.840)	0.886 (0.882-0.893)	0.916 (0.919-0.927)
0.5				0.689 (0.675-0.705)	0.794 (0.792-0.808)	0.852 (0.860-0.870)
0.7					0.686 (0.690-0.710)	0.789 (0.800-0.808)
0.8					0.623 (0.616-0.652)	0.740 (0.766-0.776)

(Values in parentheses are those given in reference (8) for compounds with a critical compressibility factor of 0.25 and 0.29 respectively.)

ACKNOWLEDGMENT

This report is abstracted in part from two theses by Herbert B. Ford and Raynor T. Sebulsky (on file at the Carnegie Institute of Technology Library).

NOMENCLATURE

b	—	Slope of fugacity coefficient isotherm: defined by equation (3).
f	—	Fugacity of pure component.
$\bar{f}$	—	Fugacity of a component in a mixture.
H	—	Enthalpy of a pure component.
$\bar{H}$	—	Partial molal enthalpy.
P	—	Pressure.
P_c	—	Critical pressure.
P_r	—	Reduced pressure P/P_c.
r	—	Arbitrary constant (see equation (24)).
R	—	Gas constant.
T	—	Absolute temperature.
Tc	—	Absolute critical temperature.
Tr	—	Reduced temperature T/T_c.
V	—	Molal volume.
x	—	Mol fraction in liquid phase.
y	—	Mol fraction in vapor phase.
z	—	Mol fraction in vapor or liquid phase.
Z	—	Compressibility factor = PV/RT.
Z_c	—	Critical compressibility factor = $P_c V_c/RT_c$.
γ	—	Activity coefficient, defined by equation (1).
ω	—	Arbitrary constant, defined by equation (23).
ω°	—	Zero temperature intercept of ω vs T curve

SUPERSCRIPTS

V	—	Vapor phase.
L	—	Liquid phase.
′	—	Mixture properties.
°	—	Ideal gas standard state.
□	—	Equilibrium vapor pressure.

SUBSCRIPTS

i	—	ith component.
mix	—	Mixture properties.
1	—	Component 1.
2	—	Component 2.

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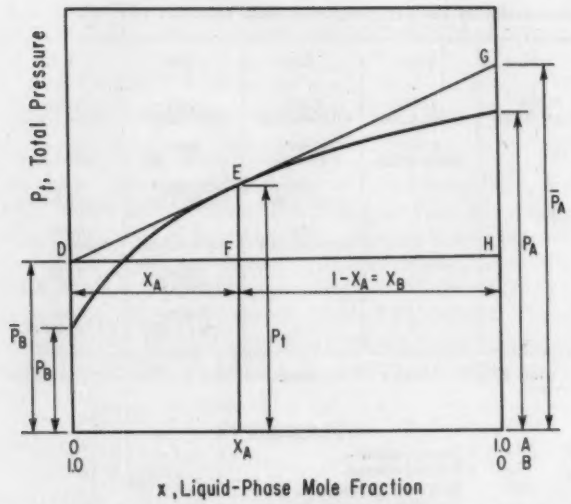

FIGURE 1—Total pressure concentration plot: It's the basis for this graphical method.

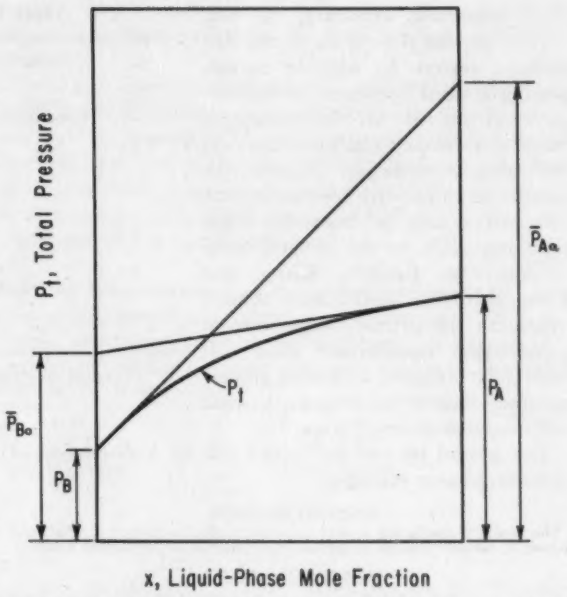

FIGURE 2—Interpretation of tangential intercepts: It shows the significance of partial molar vapor pressure.

Predicting V-L Equilibrium Data . . .

. . . at constant temperature for binary mixtures. This graphical method is developed from a new hypothesis.

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A NEW HYPOTHESIS permits the graphical determination of vapor-liquid equilibrium under isothermal condition. The hypothesis was derived for non-ideal binary systems. At the present time, some evidence exists that the hypothesis holds satisfactorily for binary systems with moderately non-ideal behavior. However, more experimental proof is needed for its general validity.

The Hypothesis. According to the hypothesis, the partial pressures of the components of a system at constant temperature may be considered as the partial molar properties. When the total pressure of a binary system at a certain temperature is plotted against the mole fraction of a component in the liquid phase, the tangential intercept of this curve would represent the "partial molar vapor pressure" of the respective component at a certain composition. The partial pressure of a component is therefore equal to the product of its partial molar vapor pressure and its mole fraction in the liquid phase.

Figure 1 shows a plot of the total pressure (P_t) of a binary system of A and B at a constant temperature vs. the mole fractions in the liquid phase (x_A and x_B). A tangent is drawn to the curve at point E. Let $\bar{P}_A$ be the ordinate of the tangential intercept G at $x_A = 1.0$. Similarly, let $\bar{P}_B$ be that of D at $x_B = 1.0$. A line DH is drawn perpendicular to EF and GH. It can be seen then the following relationship holds for the similar triangles $\triangle DEF$ and $\triangle DGH$.

$$EF : GH = DF : DH$$

The above equation can be expressed in terms of P_t, $\bar{P}_A$, $\bar{P}_B$, and mole fractions as follows:

$$(P_t - \bar{P}_B) : (\bar{P}_A - \bar{P}_B) = x_A : 1$$

Or,

$$P_t = \bar{P}_A x_A + \bar{P}_B (1 - x_A) \quad (1)$$

Since $x_A + x_B = 1$ for a binary system, we have

$$P_t = \bar{P}_A x_A + \bar{P}_B x_B \quad (2)$$

Where $O \leq x_A \leq 1$ and $O \leq x_B \leq 1$. Equation (2)

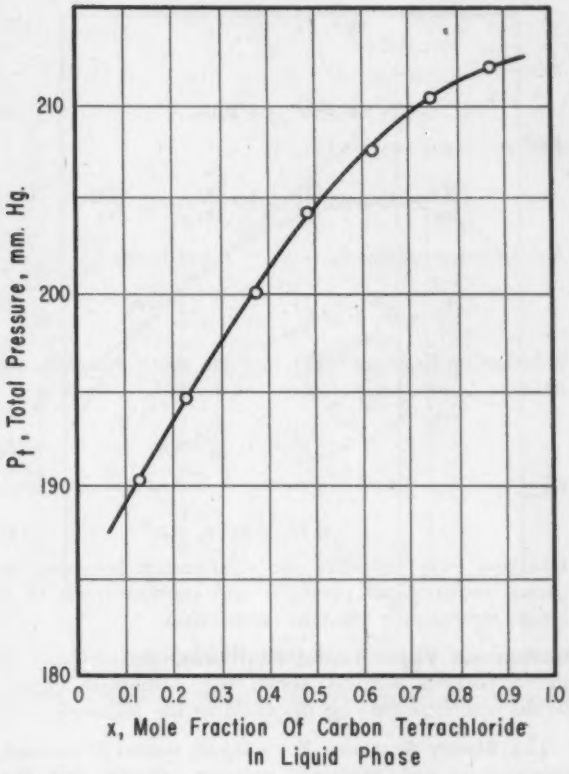

FIGURE 3—Total pressure versus liquid phase composition for the system carbon tetrachloride-benzene.

states that the total pressure P_t of a binary system is equal to the sum of products of the tangential intercept on an isothermal P_t —x plot and the respective mole fraction in the liquid phase.

According to the concept of activity coefficient, the partial pressure of a component in a non-ideal system may be expressed by the following equations.

$$p_i = \gamma_i P_i x_i$$

Therefore, for a binary system of A and B,

$$P_t = p_A + p_B$$

$$P_t = \gamma_A P_A x_A + \gamma_B P_B x_B \qquad (3)$$

where $0 \leq x_A \leq 1$ and $0 \leq x_B \leq 1$.

Mathematically, the necessary and sufficient conditions for Equations (2) and (3) to exist simultaneously are:

$$\gamma_A P_A = \bar{P}_A$$

$$\gamma_B P_B = \bar{P}_B$$

It follows that

$$\bar{P}_A x_A = p_A \qquad (4)$$

$$\bar{P}_B x_B = p_B \qquad (5)$$

Consider now the tangential intercept $\bar{P}_A$ at $x_A = 1.0$ as a fictitious vapor pressure of component A in the mixture. It can be seen that Equation (4) has the form of Raoult's Law. Since the Raoult's Law regards the vapor pressure of a pure component as a molar property, the tangential intercept is consequently considered as the partial molar vapor pressure of a component. Thus, the partial pressure of component A in the mixture equals its partial molar vapor pressure times the mole fraction x_A. The same is true for component B, as is stated by Equation (5).

Theoretical Consideration. The physical significance of the partial molar vapor pressure may be stated as follows. The partial pressure of a component in a homogeneous binary system, ideal or non-ideal, follows a general equation in the following:

$$p_i = \bar{P}_i x_i \qquad (6)$$

For ideal systems at a constant temperature, the total pressure (P_t) is linear with the concentration in the liquid phase (x). Equation (6) reduces to Raoult's Law as shown below:

$$p_i = P_i x_i \qquad (7)$$

Hence

$$\bar{P}_i = P_i \qquad (8)$$

For non-ideal systems at constant temperature, the tangential intercepts of an isothermal P_t — x plot bear resemblance to the activity coefficients of non-ideal components in that they change with concentrations. Referring to Figure 2, the intercept at $x_A = 1.0$ may be seen to range from $\bar{P}_{A0}$ to P_A. For a system containing only component A, the tangential intercept of $x_A = 1.0$ equals exactly the vapor pressure of pure component A. For a system containing only component B, the tangential intercept at $x_A = 1.0$ is $\bar{P}_{A0}$, which represents the maximum value of $\bar{P}_A$. Since $x_A = 0$ for such a system,

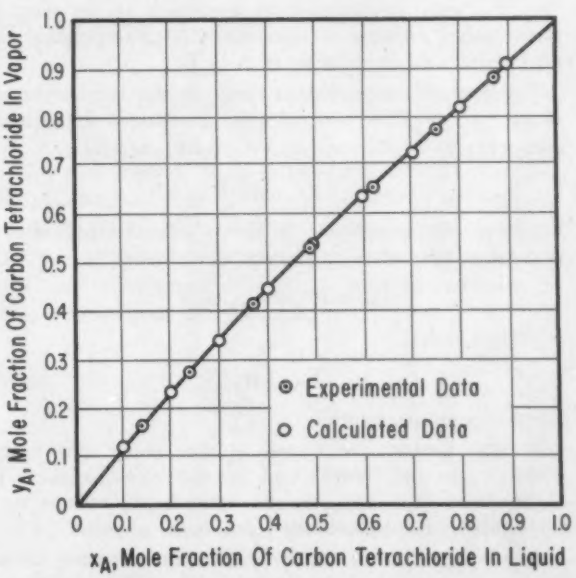

FIGURE 4—Equilibrum diagram of system carbon tetrachloride-benzene: Calculated and experimental values are in excellent agreement.

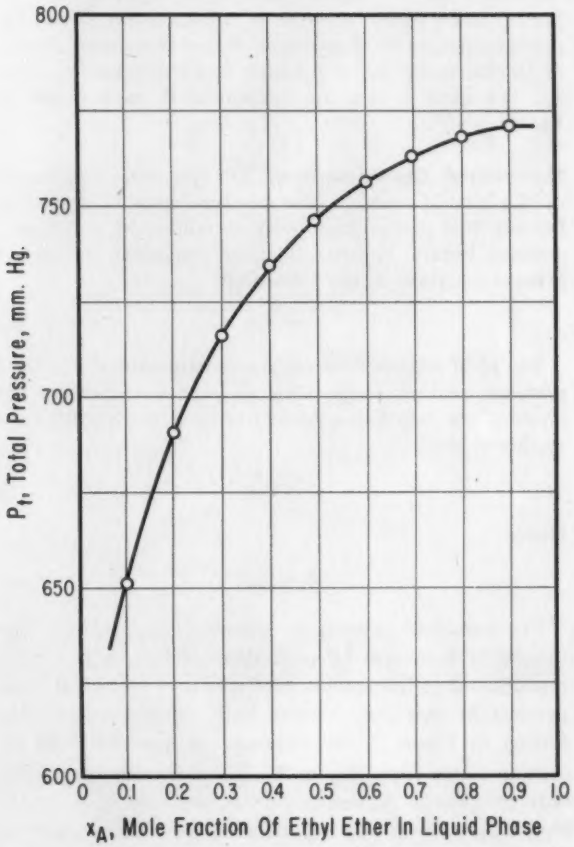

FIGURE 5—Total pressure versus liquid-phase composition for system ethyl ether-methyl iodide.

it is true that $p_A = (\bar{P}_{AO})(0) = 0$ according to Equation (6). $\bar{P}_{AO}$ may nevertheless be regarded as the partial molar vapor pressure of component A corresponding to an infinitely dilute solution of A in B.

For a small concentration range in the neighborhood of $x_A = 0$, the $P_t = x$ curve may be assumed linear and consequently $\bar{P}_{AO}$ is constant. We have, therefore

$$p_A = \bar{P}_{AO}\, x_A \text{ where } x_A \cong 0 \qquad (9)$$

Equation (9) is identical to Henry's Law which is expressed in the following conventional form:

$$p_A = H'_A \text{ when } x_A \cong 0 \qquad (10)$$

It follows that

$$\bar{P}_{AO} = H \qquad (11)$$

for a very dilute solution.

It may perhaps be stated at this point that both Raoult's Law and Henry's Law are only two special cases of Equation (6). This, on the other hand, reflects the generality of the hypothesis.

Referring again to Figure 1, the tangent line to a $P_t - x$ curve can be represented by the following equation.

$$\bar{P}_A = \bar{P}_B + \frac{\partial P_t}{\partial x_A} \qquad (12)$$

Since

$$P_t = \bar{P}_A x_A + \bar{P}_B x_B \qquad (2)$$

Differentiate Equation (2).

$$\frac{\partial P_t}{\partial x_A} = \bar{P}_A + x_A \frac{\partial \bar{P}_A}{\partial x_A} + \bar{P}_B \frac{\partial x_B}{\partial x_A} + x_B \frac{\partial \bar{P}_B}{\partial x_A}$$

For a binary system, $x_A + x_B = 1$ and hence $\frac{\partial x_B}{\partial x_A} = -1$.

$$\frac{\partial P_t}{\partial x_A} = \bar{P}_A + x_A \frac{\partial \bar{P}_A}{\partial x_A} - \bar{P}_B + x_B \frac{\partial \bar{P}_B}{\partial x_A}$$

Substituting Equation (12) into the above equation, we have

$$x_A \frac{\partial \bar{P}_A}{\partial x_A} + x_B \frac{\partial \bar{P}_B}{\partial x_A} = 0 \qquad (13)$$

Or,

$$x_A\, \partial \bar{P}_A + x_B\, \partial \bar{P}_B = 0 \qquad (14)$$

Equation (14) expresses the relationship between the partial molar vapor pressures and concentrations of a binary system at a constant temperature.

Isothermal Vapor-Liquid Equilibria. On the basis of the hypothesis derived above the isothermal vapor-liquid equilibria may be discussed in the following.

(1) Binary Systems. For a binary system at constant temperature and moderate pressure, assume that the Dalton's Law holds for the vapor phase. The partial pressure of one of the components is then equal to

$$p_i = P_t y_i = \bar{P}_i x_i \qquad (15)$$

Hence,

$$y_i = \frac{\bar{P}_i x_i}{P_t} \qquad (16)$$

Equation (16) indicates that the vapor phase com-

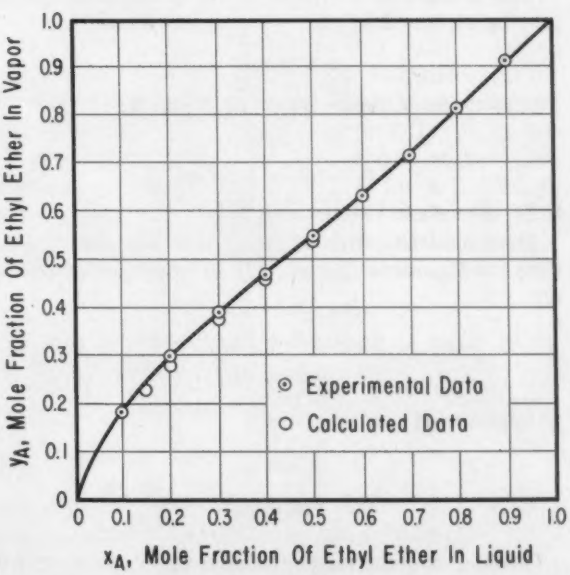

FIGURE 6—Equilibrium diagram of system ethyl ether-methyl iodide: Again, calculated and experimental values are very close.

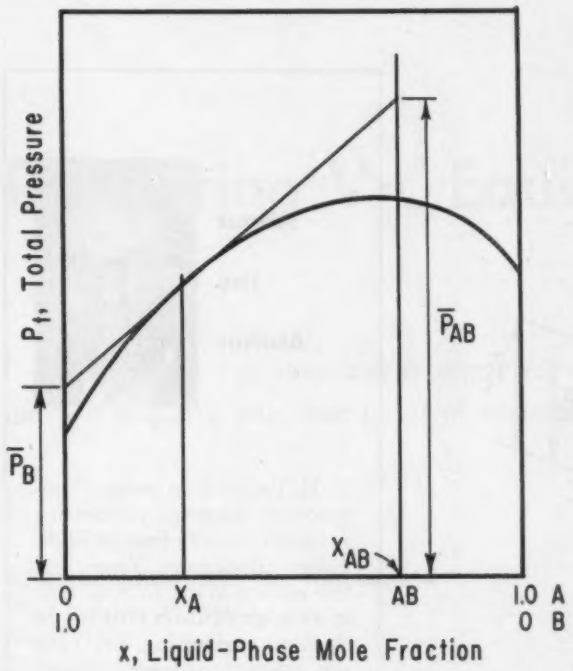

FIGURE 7—Azeotropic binary system: These systems must be treated in a special way.

TABLE 1

Graphical Calculation of Phase Equilibrium

System: Carbon tetrachloride—Benezene at 40° C

A—Carbon Tetrachloride B—Benzene

x_A	$\bar{P}_A$, mm Hg	P_t, mm Hg	y_A calc.
0	....	....	0
0.1	231.5	188.4	0.1228
0.2	228	193.0	0.2362
0.3	224.8	197.3	0.3418
0.4	221.7	201.0	0.4412
0.5	219.2	204.3	0.5364
0.6	216.8	207.0	0.6284
0.7	214.9	209.2	0.7191
0.8	213.6	210.9	0.8102
0.9	212.7	211.9	0.9033
1.0	212.4	212.4	1.0

TABLE 2

Graphical Calculation of Phase Equilibrium

System: Ether—Methyl iodide at 35° C

A—Ether B—Methyl iodide

x_A	$\bar{P}_A$, mm Hg	P_t, mm Hg	y_A calc.	y_A expt.
0	....	....	0	....
0.15	997	672.5	0.222	....
0.2	947	690.3	0.274	0.2952
0.3	866.5	716.1	0.363	0.3843
0.4	825	734.1	0.449	0.4653
0.5	800.5	746.8	0.536	0.5440
0.6	787.8	755.8	0.625	0.6252
0.7	781.3	762.8	0.717	0.7140
0.8	776.8	768.1	0.809	0.8096
0.9	774	771.5	0.903	0.9050
1.0	....	....	1.0	....

position of a component can be calculated from the knowledge of P_t, $\bar{P}_i$ and x_i.

In other words, the analysis of vapor-phase composition of a binary system may be avoided in the study of phase equilibria. Actually, the total pressure (P_t) of a binary system may readily be determined as a function of its liquid-phase composition (x) by experimental methods. The partial molar vapor pressure ($\bar{P}$) can then be determined graphically from the $P_t - x$ plot. Such procedure is of considerable value in estimating the phase equilibria of those systems which offers extreme difficulties in the analysis of vapor-phase composition. The system butadiene-styrene may be mentioned as a good example.

The systems, carbon tetrachloride-benzene, and ether-methyl iodide, were examined in a manner described above. Graphs and calculations are shown in Figures 3-6 and Tables 1-2. The experimental data of total pressure of the binary system[1] were first plotted against the liquid-phase composition of one component as illustrated in Figure 3. The tangential intercepts of this component on $P_t - x$ plot were obtained graphically and entered in Tables 1 and 2. The vapor-phase composition of the system was then calculated by means of Equation (16). The calculated and experimental values of vapor-phase composition plotted in Figures 4 and 6 showed excellent agreement.

(2) Azeotropic Systems. There was some evidence that a straight-forward application of this hypothesis fails to predict the isothermal phase equilibria of azeotropic systems satisfactorily. Consequently, an azeotropic system may be treated in an alternate way. Referring to Figure 7, an azeotropic system of A and B with a maximum total pressure is shown. It is assumed that a fictitious compound AB exists at the azeotropic composition. There would be then two homogeneous systems in the entire range of composition, B — AB and AB — A. For a tangent drawn to the $P_t - x$ curve of mixture B — AB, the following geometric relationship may be derived.

$$P_t = \bar{P}_{AB}\frac{x_A}{x_{AB}} + \bar{P}_B\left(1 - \frac{x_A}{x_{AB}}\right) \qquad (17)$$

The first term at the right-hand side of Equation (17) may be assumed to be the partial pressure of the fictitious compound AB. The second term would then represent the partial pressure of compound B. At moderate pressure, the vapor-phase composition may be estimated by Equation (18) in the following

Since $$y_B = \frac{p_B}{P_t}$$

Hence $$y_B = \frac{\bar{P}_B}{P_t}\left(1 - \frac{x_A}{x_{AB}}\right) \qquad (18)$$

(3) Ternary Systems. A possible generalization of the hypothesis is related to the prediction of phase equilibria of a homogeneous ternary system. This would include the experimental work of preparing a series of

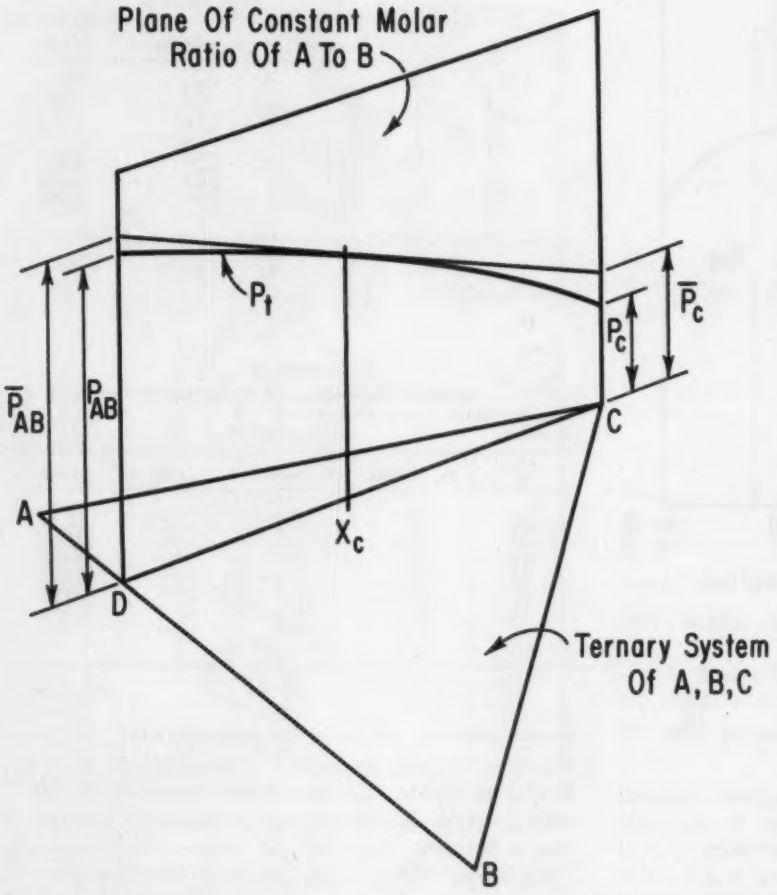

FIGURE 8—Pressure-concentration plot for a ternary system: The hypothesis may be used for this case, too.

ternary mixtures which contain approximately constant amounts of two components in the liquid phase.

Figure 8 shows the triangular diagram of such a ternary system A-B-C. The composition of this series is represented by line CD since it contains a constant amount of A and B for a concentration range from $x_C = 0$ to $x_C = 1.0$. The total pressure of the system is plotted against x_C on a vertical plane CDEF. This curve intercepts $x_C = 1.0$ at the vapor pressure of pure C. It intercepts $x_C = 0$ at P_{AB}, the total pressure of a binary system A-B alone. A tangent is drawn to the $P_t - x_C$ curve. The tangential intercepts are designated as $\bar{P}_{AB}$ at $x_C = 0$ and P_C at $x_C = 1.0$. It may be shown that

$$P_t = \bar{P}_{AB}(1 - x_C) + \bar{P}_C x_C \qquad (19)$$

In accordance with the hypothesis of tangential intercept, the term $\bar{P}_C x_C$ in Equation (19) is to represent the partial pressure of C in the ternary system. The vapor-phase concentration y_C would therefore be estimated by the following equation.

$$y_C = \frac{\bar{P}_C x_C}{P_t} \qquad (20)$$

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Comment

The phase equilibria of a few binary systems of hydrocarbons were also examined according to Equation (16) and showed satisfactory agreement with experimental data in the literature. Experimental work pertaining to the extensive evaluation of the hypothesis, however, is not available at this time. The author welcomes any criticism, suggestion and assistance for the development of this proposed hypothesis.

NOMENCLATURE

A, B, C, i = components in a homogeneous mixture
p = partial pressure of component
$\underline{p}$ = vapor pressure of a pure component
$\bar{P}$ = tangential intercept on a $P_t - x$ plot, or partial molal vapor pressure of a component in a mixture
P_t = total pressure of a homogeneous mixture
x = mole fraction of a component in the liquid phase
y = mole fraction of a component in the vapor phase
γ = activity coefficient

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Predicting V-L Equilibrium Data . . .

. . . at constant pressure for binary mixtures. This "activity coefficient" method requires only one point of experimental data and eliminates trial and error.

R. S. Schechter and M. Van Winkle
The University of Texas
Austin, Texas

THE DESIGN ENGINEER is often faced with the problem of computing vapor-liquid equilibrium data for binary or pseudobinary systems before preliminary design of distillation equipment can be made. This article presents a systematic method of computing vapor-liquid equilibrium data from a single point of experimental data utilizing the Carlson and Colburn[2] form of the Van Laar[4] equation. No trial-and-error is involved and the technique is easily adaptable to machine computation since all calculations are arranged in a logical, straightforward manner.

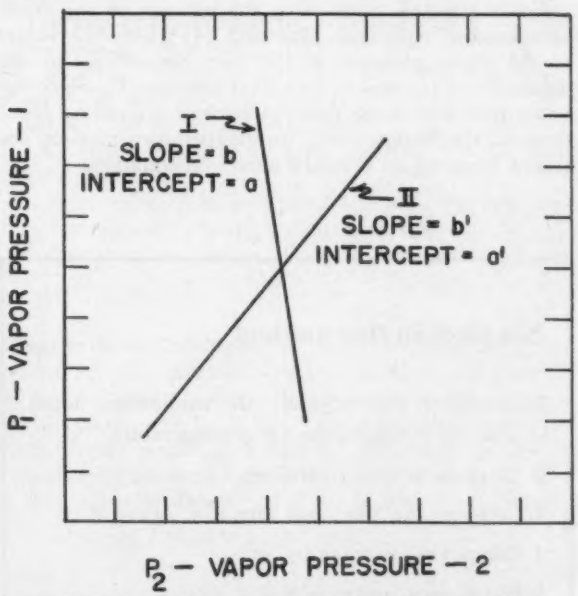


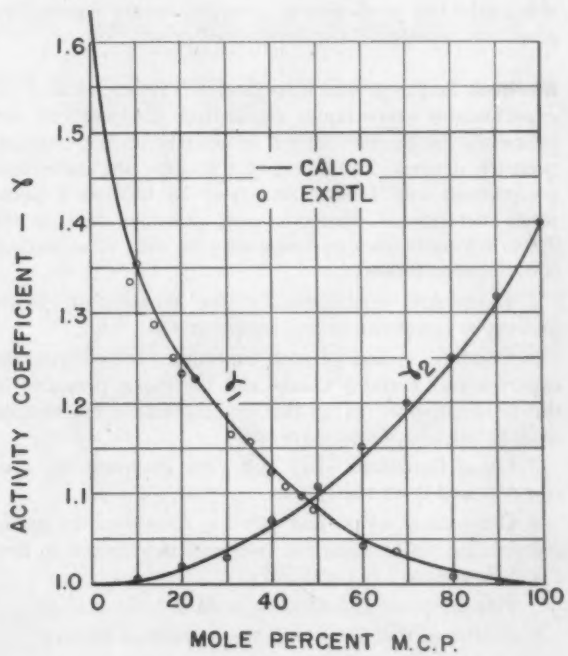
FIGURE 1 (above)—Plot of Equations 3a and 4 for one value of x: Trial and error is eliminated in t-x computation.

FIGURE 2 (right)—Activity coefficient-composition plot for system methylcycopentane-benzene: Calculated results agree very well with experimental.

Carlson and Colburn assumed the ratio of the constants, $\frac{A}{B}$ to be equal to the ratio of the effective molal volumes of two components in a binary mixture and based on this assumption expressed the Van Laar equations as follows:

$$\log \gamma_1 = \frac{Ax_2^2}{\left(\frac{A}{B}x_1 + x_2\right)^2} \qquad (1a)$$

$$\log \gamma_2 = \frac{Bx_1^2}{\left(x_1 + \frac{B}{A}x_2\right)^2} \qquad (1b)$$



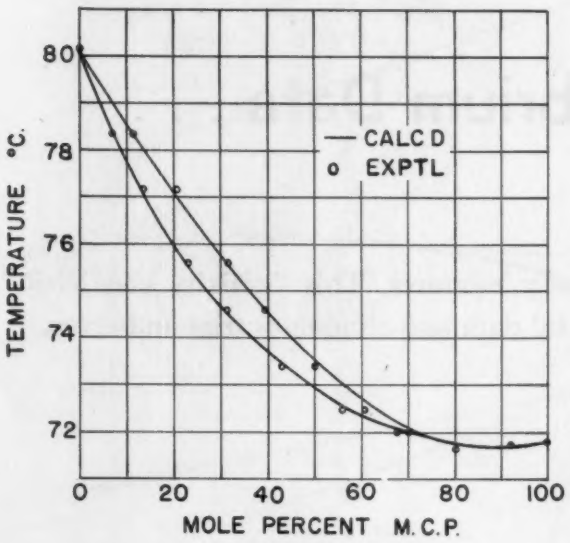


FIGURE 3—Temperature-composition plot for the same system.

where

$$\gamma = \frac{yP_t}{xP} \qquad (1c)$$

$$A = \log \gamma_1 \left[1 + \frac{x_2 \log \gamma_2}{x_1 \log \gamma_1} \right]^2 \qquad (2a)$$

$$B = \log \gamma_2 \left[1 + \frac{x_1 \log \gamma_1}{x_2 \log \gamma_2} \right]^2 \qquad (2b)$$

Equations 1a, 1b, 1c, 2a, and 2b are those to be used in this method of prediction of complete binary system data from one experimentally determined point.

Method. In the proposed method it is necessary that the experimental vapor-liquid equilibrium compositions and temperatures be determined accurately at the constant pressure desired. For azeotropic systems the azeotropic composition and temperature may be utilized if accurately determined. However, any point of data in the 0.4 to 0.6 mole fraction range may be used. The method is outlined as follows:

1. Determine experimentally the equilibrium liquid and vapor compositions and temperature.
2. Compute γ_1 and γ_2 using Equation (1c) wherein the experimental x and y values and the vapor pressures of the pure components at the experimentally determined equilibrium temperature are used.
3. Using Equations (2a) and (2b) compute the constants A and B for the system.
4. Compute γ_1 vs. x_1 and γ_2 vs. x_2 data over the entire composition range using the constants determined in step 3 and Equations (1a) and (1b).
5. Plot the γ_1 vs. x_1 and γ_2 vs. x_2 data.
6. Calculate the t — x and t — y data as follows:

Since

$$\gamma_1 = \frac{y_1 P_t}{x_1 P_1} \text{ and } \gamma_2 = \frac{y_2 P_t}{x_2 P_2}$$

and $y_1 + y_2 = 1.0$

$$P_1 = \frac{P_t}{\gamma_1 x_1} - \frac{(\gamma_2 x_2)}{\gamma_1 x_1} P_2 \qquad (3)$$

Equation (3) is an equation of a family of straight lines on a P_1 vs. P_2 plot where the slope, $b = -\frac{\gamma_2 x_2}{\gamma_1 x_1}$ and the intercept, $a = \frac{P_t}{\gamma_1 x_1}$

Thus for any assumed or fixed value of x_1 equation (3a) may be written

$$P_1 = a + bP_2 \qquad (3a)$$

In order to compute the equilibrium temperature for any given value of P_t and x_1 (which fixes x_2, γ_1, and γ_2), one would normally assume a temperature, obtain the vapor pressures of pure components 1 and 2, substitute the values of x_1, x_2, γ_1, γ_2, and P_2 in equation (3) and calculate P_1. If the calculated P_1 agreed with the vapor pressure of component 1 corresponding to the assumed temperature, the temperature was correctly assumed. If not, a new temperature would be assumed and the procedure repeated until agreement was obtained.

Here's the Direct Solution. This trial and error computation may be eliminated if it is assumed that the variation of the vapor pressure of component 1 with temperature is related to the variation of the vapor pressure of component 2 by equation (4)

$$P_1 = a' + b'P_2 \qquad (4)$$

Equation (4) will usually apply over the temperature ranges encountered in most binary systems.

For a selected value of x_1 the solution of the linear simultaneous equations (3a) and (4) yields the values of the vapor pressures of the pure components at the assumed composition x_1 and total pressure, P_t. Since the vapor pressures of the pure components are unique functions of the temperature, the temperature may be obtained from vapor pressure charts or equations.

Six steps in this method . . .

1. Determine experimentally the equilibrium liquid and vapor compositions and temperature.
2. Compute activity coefficients.
3. Compute the Van Laar constants, A and B.
4. Compute γ_1 vs. x_1 and γ_2 vs. x_2.
5. Plot γ_1 vs. x_1 and γ_2 vs. x_2.
6. Calculate t — x and t — y data.

TABLE 1
Antoine Constants for the Benzene Methylcyclopentane System (1)

Compound	A	B	C
Benzene	6.90565	1211.033	220.790
Methylcyclopentane	6.86283	1186.059	226.042

Antoine Equation: $\log_{10} P = A - \frac{B}{C+t}$

where P is the vapor pressure, mm Hg
t is the temperature, °C.

TABLE 2—Calculated Results

x_1	γ_1	γ_2	$a = \frac{P_T}{\gamma_1 x_1}$	$b = \frac{\gamma_2 x_2}{\gamma_1 x_1}$
0.1	1.3436	1.0043	5,656.45	—6.72723
0.2	1.2532	1.0167	3,032.24	—3.24512
0.3	1.1820	1.0365	2,143.26	—2.04610
0.4	1.1263	1.0639	1,686.94	—1.41690
0.5	1.0833	1.0982	1,403.12	—1.01375
0.6	1.0509	1.1397	1,205.32	—0.72300
0.7	1.0274	1.1885	1,056.75	—0.49577
0.8	1.0117	1.2445	939.01	—0.30753
0.9	1.0028	1.3072	842.08	—0.14484

x_1	a′	b′	ab′-a′b	b′-b	P_1	t	$y = \frac{x_1 P_1 \gamma_1}{P_t}$
0.1	48.4	1.21668	7,207.69	7.94391	907.32	77.68	0.160
0.2	48.4	1.21668	3,846.33	4.46180	862.06	75.96	0.284
0.3	48.4	1.21668	2,706.69	3.26278	829.57	74.69	0.387
0.4	48.4	1.21668	2,121.04	2.63358	805.38	73.71	0.477
0.5	48.4	1.21668	1,756.21	2.23042	787.39	72.96	0.561
0.6	48.4	1.21668	1,501.92	1.93968	774.31	72.42	0.624
0.7	48.4	1.21668	1,309.72	1.71245	764.82	72.02	0.724
0.8	48.4	1.21668	1,157.36	1.52421	759.32	71.78	0.809
0.9	48.4	1.21668	1,031.55	1.36152	757.65	71.71	0.900

Solving equation (4) for P_2 and substituting in equation (3a) yields

$$P_1 = \frac{ab' - a'b}{b' - b} \quad (5)$$

The value of b′ may be obtained from the vapor pressures of the two components at two different temperatures (usually selected in the range of temperatures expected to be covered by the binary data).

Thus

$$b' = \frac{P_{1t_1} - P_{1t_2}}{P_{2t_1} - P_{2t_2}} \quad (6)$$

$$a' = P_{1t_1} - b'P_{2t_1} \quad (7)$$

The values of a′ and b′ are considered constant for a given system.

The step-wise procedure for evaluating the t — x and t — y data then becomes.

a. Calculate values of a and b for various assumed values of x_1 and plot a vs. x_1 and b vs. x_1

b. Calculate the values of a′ and b′

c. Calculate values of P_1 using equation (5) for various values of x_1

d. From vapor pressure charts determine the temperature corresponding to the various values of x_1

e. Calculate the values of y_1 corresponding to the values of x_1 from $y_1 = \frac{\gamma_1 x_1 P_1}{P_t}$

Step-By-Step Example. In order to familiarize the reader with the mechanics of the technique, an example of the calculation method is demonstrated here using a datum point given by Myers.[3] The atmospheric pressure, vapor liquid equilibrium data for the system methylcyclopentane-benzene will be computed.

The following data are given by Myers:[3]

$x_1 = 0.096$, $y_1 = 0.155$ at t = 77.8 C.

where

x_1 = Mole fraction methylcyclopentane in the liquid.
y_1 = Mole fraction methylcyclopentane in the vapor.

Step I. Calculation of A and B.

(The subscript 1 denotes methylcyclopentane in all sample calculations and the nomenclature is consistent with that given in the paper.)

Using the Antoine constants given in Table 1, the vapor pressures of both components at 77.8 C. were calculated to be $P_1 = 910.5$ mm, and $P_2 = 707.6$ mm. Then from equation (1c):

$$\gamma_1 = \frac{(0.155)\ (760)}{(0.096)\ (910.5)} = 1.3477$$

Similarly,

$$\gamma_2 = \frac{(0.845)\ (760)}{(0.904)\ (707.6)} = 1.00395$$

Substituting the values of γ_1, γ_2, x_1 and x_2 into equation (2a):

$$A = 0.12959\left\{1 + \left[\frac{(0.904)\ (0.001712)}{(0.097)\ (0.12959)}\right]\right\}^2 = 0.16384.$$

Similarly, using equation (2b):

$B = 0.13986.$

Step II. Calculation of γ_1 and γ_2 at fixed intervals of x_1.

The activity coefficients at intervals of x_1 are calculated by means of equations (1a) and (1b).

For example at $x_1 = 0.1$

$$\log \gamma_1 = \frac{Ax_2^2}{\left(\frac{A}{B}x_1 + x_2\right)^2} = \frac{(0.16384)\ (0.9)^2}{\left[\frac{(0.16386)}{(0.13986)}\ (0.1) + 0.9\right]^2}$$

$$= 0.12827$$

and

$$\gamma_1 = 1.3436$$

In the same manner the activity coefficient for benzene at $x_1 = 0.1$ is $\gamma_2 = 1.0043$.

The calculated activity coefficients at various assumed values of x_1 are shown in Table 2.

Step III. Calculation of a and b.

By definition

$$a = \frac{P_t}{\gamma_1 x_1}$$

and

$$b = -\frac{\gamma_2 x_2}{\gamma_1 x_1}$$

hence at x = 0.1,

(Continued on Next Page)

$$a = \frac{760}{(1.3436)\ (0.1)} = 5656.45$$

and

$$b = -\frac{(1.0043)\ (0.9)}{(1.3436)\ (0.1)} = -6.72723$$

Line I on Figure 1 represents graphically equation (3) for $x_1 = 0.1$.

The calculated values of a and b are also tabulated in Table 2.

Step IV. Calculation of a′ and b′.

The values of a′ and b′ are constant when a linear relationship is assumed between P_1 and P_2. Thus a′ and b′ can be calculated from the vapor pressures of the two components at two temperatures.

Using the Antoine equation (Table 1):

At t = 85 C.

$P_1 = 1121.1$ mm Hg and $P_2 = 881.7$ mm Hg

At t = 70 C.

$P_1 = 718.5$ mm Hg and $P_2 = 550.8$ mm Hg.

From equation (6)

$$b' = \frac{1121.1 - 718.5}{881.7 - 550.8} = 1.21668$$

From equation (7)

$$a' = 1121.1 - (1.21668)\ (881.7) = 48.4.$$

Line II on Figure 1 represents graphically equation (4) relating the vapor pressures of the components.

Step V. Calculation of y_1 and t at different values of x_1.

Equation (5) is employed to determine the vapor pressure of methylcyclopentane at the equilibrium temperature for the particular value of x_1 in question.

For example at $x_1 = 0.1$

$$P_1 = \frac{ab' - a'b}{b' - b} = \frac{(5656.45)\ (1.21668) - (48.4)\ (-6.72723)}{(1.21668) - (-6.72723)}$$

$P_1 = 907.32$ mm Hg

The temperature which yields a vapor pressure of 907.32 mm Hg for methylcyclopentane is 77.68 C. (determined from Antoine equation).

Note that

$$y_1 = \frac{\gamma_1 x_1 P_1}{P_t}$$

Consequently at x = 0.1

$$y_1 = \frac{(1.3436)\ (0.1)\ (907.32)}{760} = 0.160.$$

The values of t and y_1 for other assumed values of x_1 can be computed as above.

The results are presented in Table 2. Figures 2, 3, and 4 show plots of calculated γ — x, t — x, t — y, and x — y and also the experimental values given by Myers.

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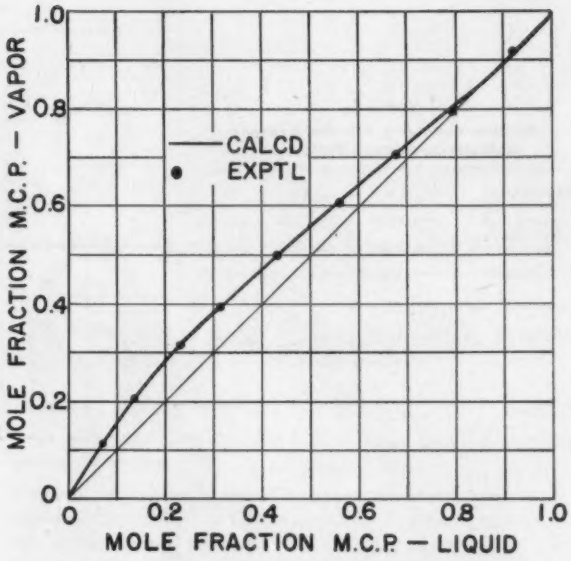

FIGURE 4—Vapor-liquid equilibrium plot for the same system.

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Particle Size Affects Initial Fluidization

Here's an interpretation of incipient fluidization deduced from particle size and distribution.

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Part VI presents a key to better understanding of the observations reported in the field of fluidization by defining incipient fluidization as it relates to particle size distribution. Part V—"The Mechanics of Fluidization" which appeared in the July REFINER gave a method for computing incipient fluidization rates and velocity-bed densities.

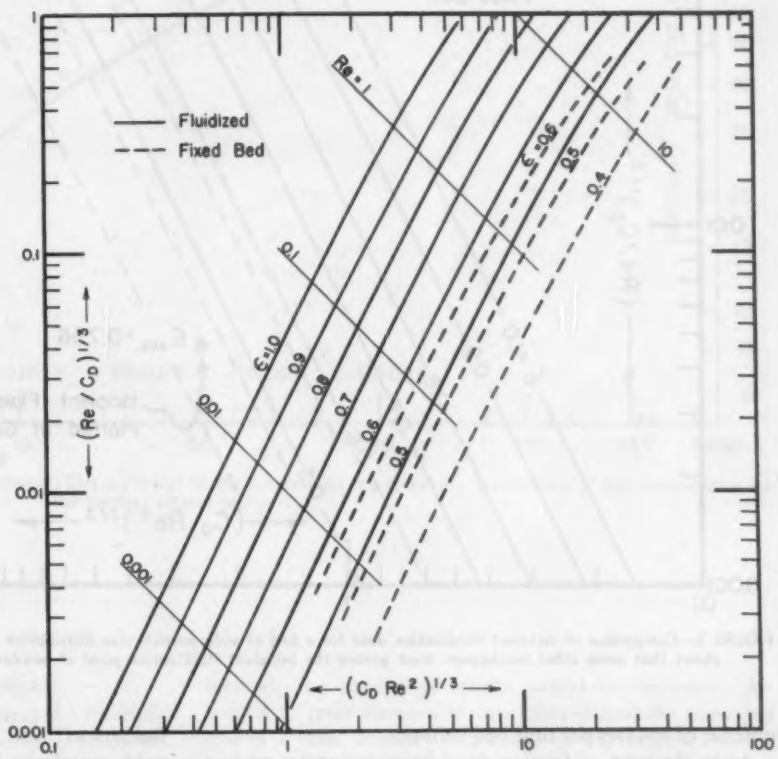

FIGURE 1—Comparison between fluidized and fixed bed pressure drop correlation. The dashed lines represent fixed bed pressure drop correlations from Leva. The solid lines are for fluidized beds. Keep in mind that fixed bed correlations are subject to as much as 50 percent deviations from experimental data.

THE POINT of incipient fluidization is generally defined as the lowest superficial fluid velocity at which the pressure drop across the bed (at its loosest packed density —Figure 2 of Part V in this series) equals the weight of the bed charge. At this point a slight increase in fluid velocity should cause an incremental lifting or expansion of the bed and create the dense "fluid" state in which the bed particles rest more upon a cushion of the fluid than directly upon each other. Prior to fluidization, the particles present a conventional fixed bed configuration.

It would therefore seem reasonable to suppose that the incipient fluidization velocity could be computed from fixed bed pressure drop correlations in reverse. In other words, at the loosest fixed bed voidage, the velocity corresponding to a pressure drop equal to the bed bulk weight divided by the grid cross sectional area would be calculated. This procedure checks experimental observation remarkably well for beds composed of uniform size particles. In fact, the procedure is also quite satisfactory for beds exhibiting relatively narrow particle size distributions.

The approach of high density (e.g., low voidage) fluidization to fixed bed correlations is illustrated graphically in Figure 1. The dashed curves were taken from the fixed bed pressure drop correlation of Leva.[4] Leva plotted

$$f' = \frac{gD_P\Delta P}{2L\rho_f v^2}\,\frac{\varepsilon^3}{(1-\varepsilon)^2} \text{ vs } \mathrm{Re} = \frac{D_P v \rho_f}{\mu_f}$$

His values of f′ can be converted to equivalent drag coefficients, C_D, by substituting the appropriate values of voidage, ε, rewriting $\Delta P/L$ as $(\rho_P - \rho_f)$ and multiplying by the factor $8/3\ (1-\varepsilon)$.

When fluid traverses a packed bed of spheres, a force acts on the collection of spheres by virtue of the pressure drop across the bed; the total force on the collection of spheres is equal to the cross-sectional area of the bed multiplied by $g\Delta P$. The average force $\overline{F}$ acting on an individual sphere is then $g\Delta P/NL$ where N is the average

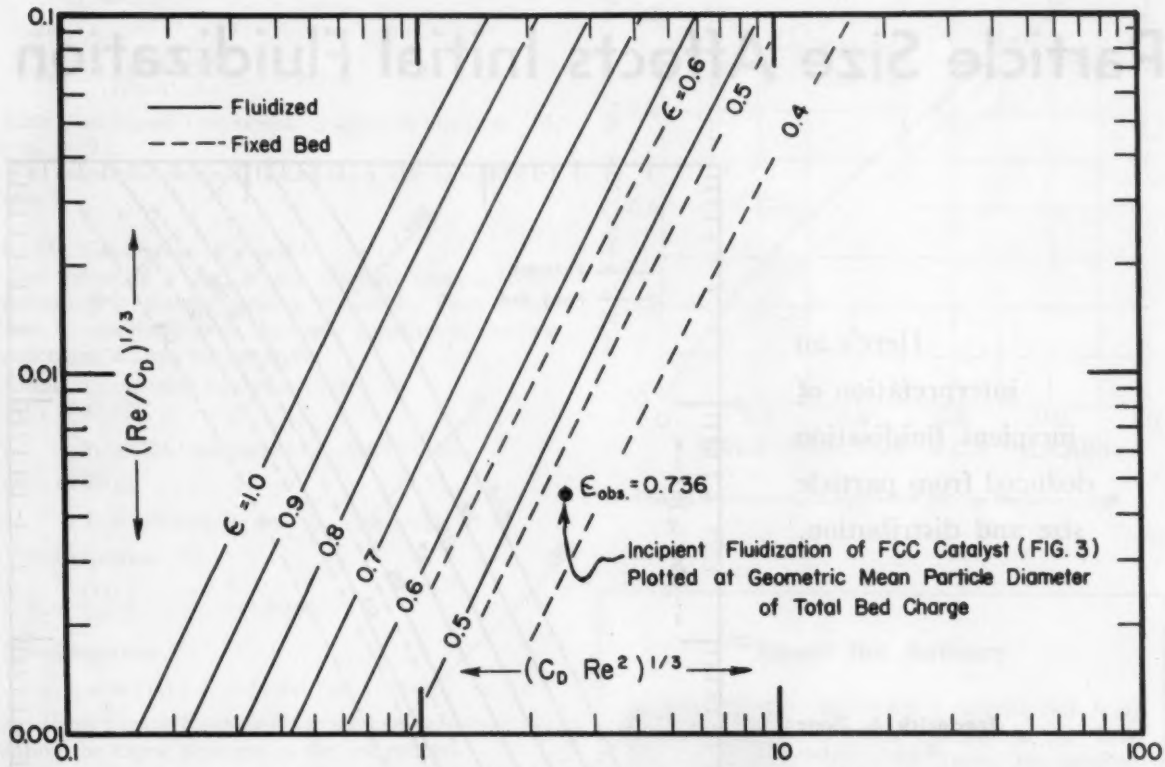

FIGURE 2—Comparison of incipient fluidization data for a bed of wide particle size distribution with fluidized and fixed bed flow correlations. This shows that some other mechanism must govern the incipient fluidization point of powders exhibiting wide particle size distributions.

number of spheres per unit bed volume.

As in the case of friction drag force acting on an isolated sphere, the average force $\overline{F}$ can be represented by:

$$\overline{F} = \frac{1}{2}\ C_D \rho_f (\pi D_P^2/4) v^2$$

where v is the superficial velocity and C_D is the mean drag coefficient. Since $N = (1-\varepsilon)/(\pi D_P^3/6)$ and $\Delta P/L = 2f\rho_f v^2/gD_P$, the drag coefficient, C_D, may be related to the bed friction factor f:

$$F = \frac{g\Delta P}{NL} = \frac{\pi f \rho_f D_P^2 v^2}{3(1-\varepsilon)} = \frac{\pi}{8} C_D \rho_f D_P^2 v^2$$

and so

$$C_D = \frac{8}{3}\frac{f}{1-\varepsilon}$$

In the case of Leva's modified f′:

$$f = f' \times \frac{(1-\varepsilon)^3}{\varepsilon^3}$$

so that for example at a voidage of 0.4:

$$f' \times \frac{8}{3}\frac{(1-\varepsilon)^2}{\varepsilon^3}\frac{1}{(1-\varepsilon)} = f' \times \frac{8}{3} \times \frac{(1-0.4)}{(0.4)^3} = 25f' = C_{D\varepsilon=0.4}$$

The dashed curves in Figure 1 were computed in this manner for $\varepsilon = 0.4$, 0.5, and 0.6. The experimental data covered a range of voidages from 0.35 to 0.58. A similar procedure can be followed in deriving the comparison between the fixed bed data of Carman,[2] Happel,[3] or Bakhmeteff and Feodoroff,[1] etc. over this range of Reynolds numbers. It should be remembered that the fixed bed correlations are subject to deviations from experimental data as great as 50 percent in some instances, so that a comparison based solely on best-fit curves (as in Figure 1) can be slightly misleading. In other words, it appears that the fluid bed drag coefficient is of the order of 20 percent less than that in a fixed bed of the same voidage, at all voidages where comparison can be made.

This difference is probably real, although the magnitude is uncertain. The fluid bed drag coefficient at higher Reynolds numbers is less than one-half the fixed bed drag coefficient. These differences doubtless reflect differences in particle arrangement, since there must be many more points of contact between particles in a fixed bed than in a fluid bed of the same voidage.

It seems quite reasonable to accept the pressure drop equivalence in fixed and fluid beds at incipient fluidization voidages for beds composed of various sized particles as well as beds of uniform size particles. However, there appears to be some limit to this, imposed probably by the actual range and distribution of the particle sizes in the bed. For example, the point of incipient fluidization with air for the sample of FCC catalyst discussed in Part V of this series deviated considerably from the curves of Figure 1. The data point for this material, plotted at its geometric mean particle diameter, is shown in Figure 2 in

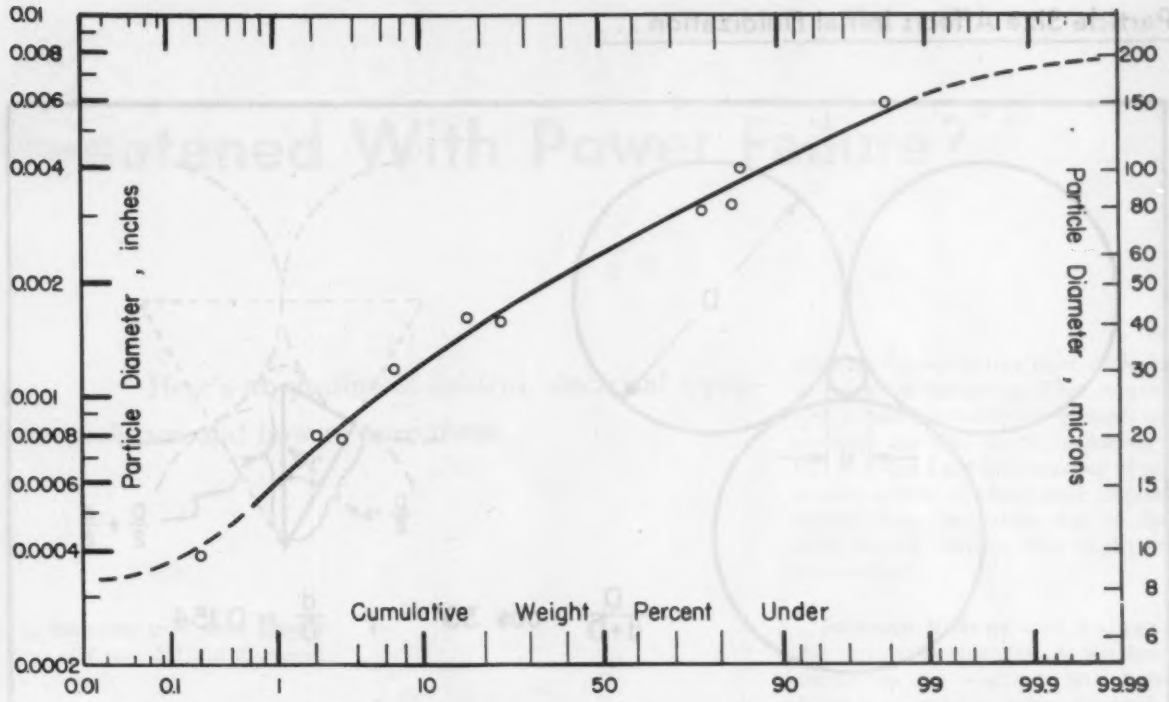

FIGURE 3—Particle size analysis of a typical FCC catalyst. This is the plot of the conventional log probability presentation of size analysis data for the catalyst plotted in Figure 2.

relation to the fixed and fluid bed correlations.

In Part V of this series it was shown that the fluidization data for this catalyst, at higher voidages, could be brought into agreement with the correlation represented by the solid curves, by plotting the data for each superficial air rate at the geometric mean particle diameter of the unelutriatable portion of the bed. This suggested a relation between entrainment, fluidization, and bed composition which should be valid over the entire "fluid" range. However, at incipient fluidization presumably no entrainment occurs and the geometric mean diameter of the total bed is the characteristic size. Nevertheless, Figure 2 shows this to be insufficient; some other mechanism must govern the incipient fluidization point of powders exhibiting wide particle size distributions.

The fact that this discrepancy occurred only with powders having about a 10 fold, 15 fold, or even greater particle size distribution, led to a reconsideration of the significance of size analyses. Figure 3 shows the conventional log probability presentation of the size analysis data for the catalyst plotted in Figure 2. Note that the data points give no indication of the existence of a maximum or minimum size of particle in the sample. Admittedly the data extend down to 0.2 weight percent at the lower end of the size spectrum and up to 98 percent at the upper end. However, the practical limitation of a maximum particle size is obvious merely upon visual inspection of a fresh drum of the material, so that extrapolation of a smooth curve (or even a straight line) drawn through the analytical results would be incorrect. Attempts to pour samples of this catalyst into the open top end of a tube, counter to a rising air stream, indicated a terminal velocity of the largest particles of about 3.5 feet per second corresponding to about 190 microns.

At the lower end of the spectrum it is not obvious to the naked eye that a minimum size is present. In fact it does not logically appear that there is necessarily a smallest size in any fresh grind; the spectrum of sizes could very well extend down to below visual limits and into the fractional micron ranges. However, the question then arises as to how such exceedingly small particles would behave in a bed; or for that matter whether they could even be retained, particularly in the size range where the forces of Brownian movement and natural convective currents in the surrounding air begin to be effective. Again it would appear that some minimum particle size must also exist, governed by the practical considerations of retainability in the bed.

Suppose for example that a bed of fine powder could be considered as being made up of layers of equal size particles arrayed in equilateral triangular pitch. Treating the particles as spheres, and considering these layers as screens, the diameter of the particle just able to pass through the opening between three adjacent spheres is about 15.4 percent of the diameter of the spheres making up the screen. This is illustrated in Figure 4.

In a bed of particles of wide size distribution any number of combinations of particle sizes could be in adjacent

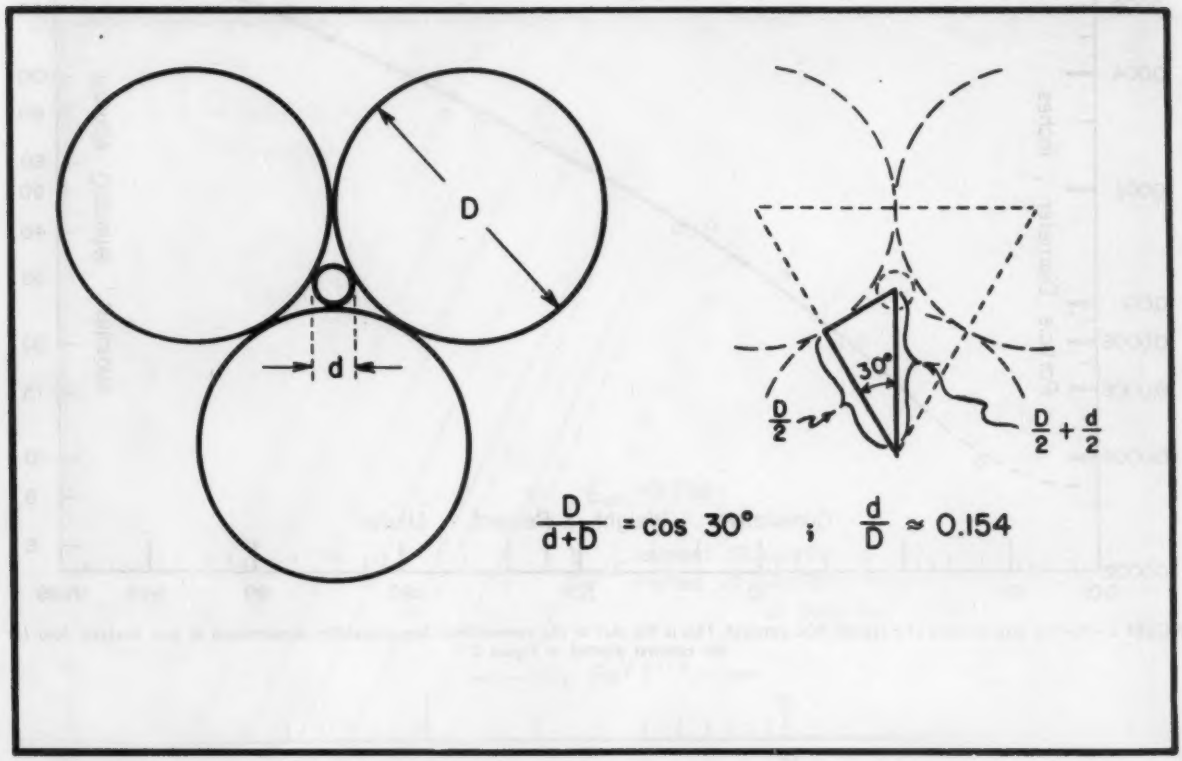

FIGURE 4—Particle screening effectiveness of spheres on equilateral triangular pitch.

triangular configuration; some affording large openings and some small. As a first approximation let us assume that an opening, at least as large as that formed by three adjacent equal size particles having diameters equal to the geometric mean particle size of the total bed, exists at all levels throughout the bed depth. This means that the bed has a retentive screening capacity for particles 15.4 percent of the geometric mean; or in the case of the catalyst shown in Figure 3 approximately 8.5 microns. Note that the figure of 15.4 percent of the geometric mean is in remarkably good agreement with the lower limit for the optimum distribution derived from bed viscosity considerations in Part II of this series.

The incipient fluidization point shown in Figure 2 corresponds to a superficial air velocity of 0.01 ft/sec. From the $\varepsilon = 1.0$ curve this velocity corresponds to the terminal or free fall velocity of a 7.6 micron catalyst particle. This is so close (within 12 percent) to the 8.5 micron approximation of the bed retention capacity, and is in itself subject to the accuracy of the air velocity measurement and the terminal velocity correlation, that it could be considered a check. In other words, it could be concluded that in a bed of wide particle size distribution:

1. All particles smaller than 15.4 percent of the geometric mean particle diameter of the total bed charge will be carried out of the bed even before incipient fluidization occurs, and

2. The incipient fluidization velocity can be calculated from the free fall drag coefficient correlations (the $\varepsilon = 1$ curve in Figure 2) as the velocity required to support a particle diameter 15.4 percent of the bed geometric mean. This means that the point plotted in Figure 2 should properly be moved horizontally to the left to coincide with the $\varepsilon = 1$ curve.

This concept of the mechanism of incipient fluidization pictures the bed being lifted when the superficial velocity becomes high enough to support particles too large to escape through the interstices of the bed. This applies only to beds with such wide particle size distributions that the geometric mean is at least 6½ times the diameter of the smallest particle. Only in such beds with high static voidages can the fines be carried out before incipient fluidization, and also sufficient volume exist for slight particle movements to block interstices and initiate bed expansion. In beds with narrow particle size distributions, bed expansion results when the frictional resistance equals the bed weight. The particles do not move to the extent of leaving the bed or of being buoyed into positions where they block interstices and thereby create the higher resistances leading to bed expansion.

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Part 7 will appear in an early issue of *Petroleum Refiner*.

Threatened With Power Failure?

Here's an outline of critical, electrical equipment problems and how to cure them.

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THE EQUIPMENT IN refineries and petrochemical plants most affected by power source difficulties and by voltage dips is almost entirely the a-c solenoid operated or controlled devices. Such devices, that are normally held in an energized position against a spring or gravity, are inherently, almost instantaneous in their drop-out following loss of voltage or reduction of voltage below their drop-out values. The normal a-c solenoid device that can be electrically closed and electrically tripped usually picks up at around 75 percent rated voltage and drops out at around 50 percent voltage. Solenoid devices requiring manual setting and voltage holding will usually be found to drop out at from 30 to 50 percent of rated voltage. If the supply voltage dips below this drop-out value for only a cycle or so, it causes the solenoid to unlatch and results in operation of the device to which it is attached. Many needless outages and shutdowns will result unless corrective measures are taken to de-sensitize these solenoid devices.

Motor Starters. The problem of the motor starters dropping out is usually the most common and fortunately the most easily corrected source of plant disturbances. The usual method of doing this it to allow the main contactor to fall out, but to bypass the starting button with an under-voltage time delay device that can be adjusted for any time delay. This will cause the motor starting switch to be closed, following restoration of voltage to normal, bringing the motor back up to speed.

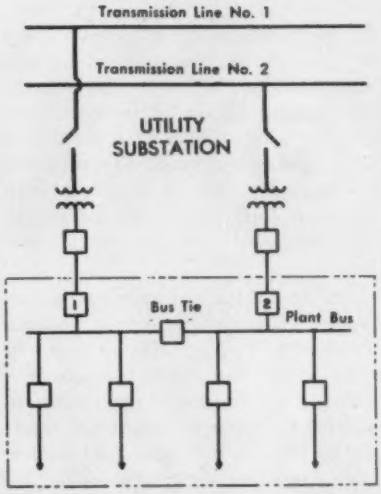


FIGURE 1—Two separate transmission circuits supply the plant's substation.

There are several general types of time delay, under-voltage devices on the market that are suitable for this service, among these are the pneumatic, mercury flow, mechanical escapement and electronic.

It is generally recommended that time delay devices be installed only on motors most critical to the plant operations and to motors most difficult to reach for restarting. This suggestion is based not only on grounds of economy but also on the inescapable fact that simultaneous restarting of all motors within a plant may impose voltage drop limitations due to the high starting currents that might be encountered.

Solenoid Valves and Relays. A-c devices in this class do not lend themselves very readily to any of the types of time delay under-voltage devices outlined above for motor starters because many of them are hand closed and electrically held and because of the fact that large variations in physical size, shape and holding and operating characteristics make it difficult to meet all requirements. Two good solutions are available, however, and conditions within a plant or process will probably determine which of the two are most desirable for a given application.

In many instances, the d-c battery control scheme will be found to offer many advantages. The d-c system is impervious to the a-c source troubles during disturbances.

The other system for supplying the various solenoids to prevent unnecessary disturbances to operations is to provide a high inertia motor-generator set for energizing the solenoids in the control systems. The motor of this set is connected to the normal a-c power circuit and the generator is connected to the auxiliary control bus handling the critical solenoids. Momentary loss of power or voltage dips leave the voltage to solenoids undisturbed.

Separate Power Sources. Figure 1 depicts supply from two separate transmission circuits not paralleled at the local substation. These two sources could be two utility transmission circuits that are available but, for vari-

ous reasons, should not be paralleled on the plant's substation. Difference in phase angle, different primary voltage class, transmission relaying problems, excess cost for transmission switching or perhaps undue, high short circuit values are some of these reasons. One of the sources could be from the utility system and the other could be the local industrial plant generating bus.

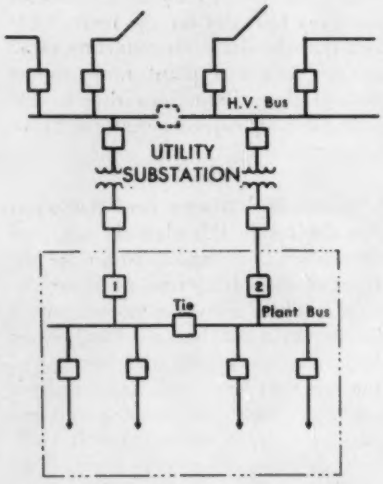


FIGURE 2—Four incoming transmission circuits supply a common bus.

This arrangement is used in some instances to supply all of the load from a predetermined preferred source and upon loss of that source, to transfer automatically to the standby feeder. Upon restoration of normal conditions on the preferred source, the load is transferred back to the preferred source. A modification that is sometimes used is to split the load between the two sources for normal operation, with the bus tie breaker being open. Following trouble on either of the two sources, the loads on the faulted feeder are transferred to the remaining good feeder by tripping the main supply breaker on the faulted circuit and then closing the bus tie breaker.

Some of the relaying features and transient phenomena associated with this operation under high speed automatic transfer will be discussed later because this arrangement is most appropriate in many instances and because very little has been published in the past to define the unusual relaying and control problems that are encountered.

Loop Circuit Transmission. This arrangement involves connection to a transmission circuit having adequate sources on each end. This circuit may be a part of a grid normally carrying "through-power" to which the industrial station is tapped. Insertion of a single transmission breaker in the line allows the line to be normally closed for power transfers, yet protects the plant's service against interruption for trouble in either direction on the transmission system. This is accomplished by connecting one of the local transformer banks to one side of the transmission breaker and the other transformer to the other side. Two sets of transmission line relaying are provided, one looking to the east and one looking to the west. Faults on the circuit to the east cause tripping of the transmission breaker and of the low voltage breaker on the transformer associated with the east line, allowing all load to be carried on the unfaulted circuit. Transformer differential is also provided on each transformer to cause clearing of the line associated with a faulted transformer.

The low voltage circuits may be arranged to operate in several fashions under this type of arrangement. In some cases, the circuits from both sources are normally operated in parallel with power directional relaying to prevent the individual feeders from cascading their troubles on the rest of the system. In other cases, where short circuit duty problems might be encountered, the low voltage buses are arranged to split-feed the loads without paralleling the transformers normally, and automatic equipment is arranged to transfer the loads from a faulted circuit to the alternate source in case of trouble.

Where it is practical to operate both transformers in parallel without short circuit duty problems, the industrial plant system is not subject to the momentary losses of synchronizing power as is experienced with the automatic transfer system. It is still subjected to any voltage flicker that might be present during time to clear faults that might originate on nearby circuits.

Three Supply Circuits. Figure 2 depicts an arrangement having four incoming transmission circuits which go to a common bus through transmission breakers. Each of the transformers is also shown equipped with a high voltage breaker, since it would not be desirable to trip the entire bus and both transformers in case of a transformer failure. The addition of a bus section breaker may still be necessary, as indicated in the dotted position, to protect against the contingency of a high voltage bushing failing on the bus side of any of the transmission breakers, or for any other bus fault contingency.

The low voltage circuits may be operated in parallel, if desired, or automatic transfer equipment may be employed, if short circuit duty dictates.

Figure 3 depicts a variation to a more conventional scheme shown in Figure 2, which may save as many as three transmission voltage breakers by connecting one of the local transformers to the line side of one of the incoming line breakers, instead of to the common bus. This arrangement is practical when the line capacity of the transmission line chosen for this connection is adequate for supplying the local load from its remote end.

Under this arrangement faults on the transmission main bus or on the transformer connected to it would cause all local transmission breakers plus the low voltage breaker of the transformer on the bus to trip, leaving the load on the line having the local transformer connected to it. For faults on the transformer connected to the line or for faults on that line, the line breaker and the low voltage breaker of the transformer would be tripped.

Automatic Transfer. It is at times desirable to have automatic transfer of loads from one source to another at the time of trouble on one circuit. This is mandatory in Figure 1 where feeders for one reason or another are not to be operated in parallel. It may be optional in any of the other arrangements. For this automatic transfer to be effective in preventing disturbances within the plant, it must be accomplished fast

enough to prevent excessive slowing down or dropping out of the various motors and other devices vital to the functioning of the continuous processes involved. This involves problems not encountered in the conventional transfer schemes where under-voltage relays are employed to initiate the transfer and where various equipment that is affected can be restarted manually

In a plant where the greater part of the electric load is motors, the regenerated voltage from the motors due to self-excitation and inertia makes it impractical in many cases to recognize the emergency condition by means of the standard under-voltage relay in sufficient time to complete the transfer before the motors and other equipment have dropped out. The possibility that there may be power factor correction capacitors and transmission line charging further aggravate the slow voltage decay rate because this shunt capacitance tends to excite the motors and in some cases over excite the motors to the extent that voltage may be higher for quite some time following loss of power than under normal condition. The regenerated voltage frequency decay is often faster than the voltage magnitude decay so that high speed under-frequency relays may be employed to get faster initiation of the transfer sequence. The under-frequency relays are set at 58.0 cycles and the under-voltage relays are set to trip on 85 percent voltage after 20 cycles, time delay.

Usually, for single line to ground faults on the supply transmission, the regenerated voltage is such that under-voltage relays are not fast enough and the under-frequency relay takes over. For line to line and three phase faults, the accompanying voltage collapse is such that the under-frequency relays do not have sufficient torque and the under-voltage relays take over.

An example is the case of a 125 hp induction motor driving a reciprocating compressor, and operating at full load. With 44.4 percent capacitors (kva in percent of hp) connected to the terminals of this motor (this amount of capacitors being about what is necessary to correct to unity power factor at full load) the voltage rose to a maximum of 150 percent after approximately 20 cycles following loss of source and did not drop to 85 percent value until after approximately 85 cycles. The frequency dropped to 58.0 cycles (96 percent in only 7 cycles). With 22.2 percent capacitors applied, the regenerated voltage did not rise above normal, but 37 cycles had elapsed before the voltage dropped to 85 percent. With no capacitors added, the voltage decrement is rapid in this case, with the 85 percent point being crossed after only approximately three cycles. As for frequency decrement, it was substantially the same for all three conditions of capacitor applications studied. The frequency dropped to 97 percent in approximately three cycles and was still being maintained at approximately 75 percent at the end of 45 cycles elapsed time, which would about coincide with the time required to complete an automatic transfer of this type.

The maximum regenerative voltage to be expected on motor circuits where excessive capacitors or line charging is present during switching is on the order of 165 to 170 percent of rating, limited by motor and transformer saturation characteristics. Power factor corrective capacitors should be eliminated or switched automatically to minimize the magnitude of this regenerated voltage, since this regenerated voltage materially affects the asymmetrical inrush current when the motors are reenergized. This current may reach approximately twenty times rated full load current or three to four times normal locked rotor values with about 22 percent capacitors when the motor is reenergized out of phase with the line voltage.

This possible high inrush phenomena has caused considerable conjecture as to possible motor winding mechanical damage and possible damaged motor shafts, but it is felt that there is little reason for concern, particularly when it is realized that considerably more severe duty has for years been imposed upon many motors connected to transmission and distribution lines where high speed reclosing in the order of 20 to 25 cycles has been the general industry practice. This is more severe than in the transfer operation where elapsed time is usually in the order of 45 to 60 cycles.

Realization that the restarting current to be expected following transfer is substantially close to locked

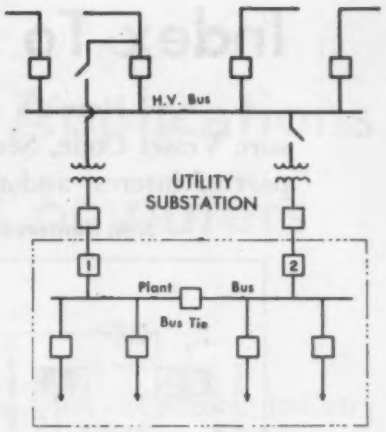


FIGURE 3—One transmission line bypasses the common bus.

rotor values, although the motor itself may be turning at speeds above 75 percent of normal, emphasizes the necessity of coordinating main circuit over current relaying to prevent unnecessary tripping. It also emphasizes the problem of possible low voltage conditions at the time of restarting a complete line of motors instead of the normal procedure of starting individual motors separately, particularly on circuits of high relative impedance. Consideration of these criteria make it desirable, in many instances, to arrange the loads within the plant for normal "split-feed" where approximately one half of the load is carried on one feeder and the remaining half on the other. With this arrangement the restarting disturbance is held to about half of the values when transferring the entire load at once.

In one actual case where an industrial load was supplied from two 12,000/20,000 kva transformers connected to independent transmission lines, it was found that approximately 12,000 kw of plant load on a single bus was the maximum amount that could be transferred without dropping the motor voltage below 65 percent normal, at which point motor torque about equals the composite torque requirements of the customer's load, making it undesirable to allow further loading. By splitting the customer's load and by transferring only one half at a time it is pactical to raise the total plant load up above 20,000 kva without voltage difficulties. This allows loading to the substation firm capacity

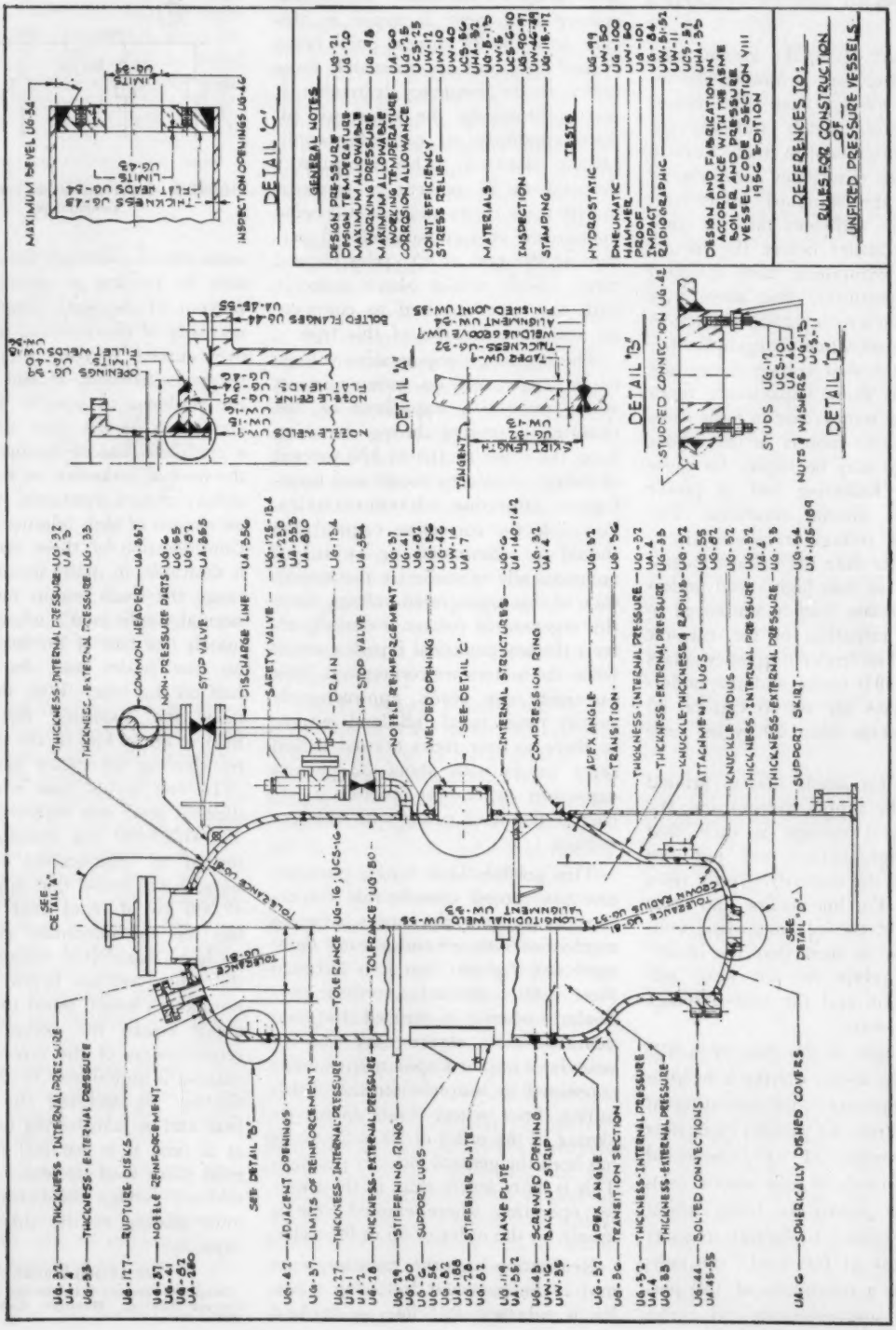
ACKNOWLEDGMENT

Originally presented before the AIEE Summer General Meeting, Montreal, Canada, June 25, 1957.

Index To New ASME Boiler Code

Here's a graphical index to the 1956 ASME Boiler and Pressure Vessel Code, Section 8. To use the index, refer to the drawing for the part of interest and note the appropriate code reference.

J. A. Hunter, Carbide and Carbon Chemicals Company, Texas City, Texas



Review These Applications of Electronic Computers

Here is a picture of what the refining industry is doing with electronic computers. You may find many of these applications can fit your work.

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PETER F. DRUCKER, renowned economist, refers to the petroleum industry as "our most nearly automated industry." He has particular reference to automatic controls, feed back, self regulation and other aspects of production automation. But in the electronic computer, another tool of automation has appeared upon the horizon and the petroleum industry is fast learning how to use it.

Automatic data processing is a tool for management in its entirety, in the opinion of C. M. Jones, Shell Oil Company. He says, "the technical man, the accountant and the management representative responsible for policy cannot be considered in separate categories in the total development of automatic computer usage."[1]

J. W. Redding, of Standard Oil Company (Indiana) agrees. At a conference on Refinery Engineering and Accounting (October, 1955), he gave a concise summarization of how his company plans to fit in a large-scale computer with its engineering and accounting functions.[2] Since that time, the applications have proceeded according to schedule.

The PETROLEUM REFINER has published a number of articles on both digital and analog computers.[3] The principles of computers and the equipment available have been well covered in many other technical journals. Hence this article will not discuss how computers work, nor catalog the attributes of various pieces of equipment.

Instead it will endeavor to summarize a number of computer applications in the petroleum refining field, pointing out the diverse uses to which electronic computers are being put. These applications will ignore the extensive uses for office and accounting use—a story in itself.

Solution of Petroleum Problems. Since computers can be applied to a variety of problems in engineering, chemistry, mathematics, accounting, finance and management control, it is inevitable that different companies have started with different problems. These problems all have one thing in common: computation volume or complexity which otherwise would have meant thousands of man hours' calculation. Following are some of the reported applications.

Socony Mobil has used a medium-scale computer in simulating all processes in a refinery to answer the question: "What finished products will we get if we charge so many crudes under the following operating conditions?"[4]

This type of computer is being used by Phillips Petroleum Company for calculations in process design, equipment design, operations research, quality control and oil production.[5]

Shell Development Company has

used another type of medium-scale computer since 1954 on a "wide range of problems involving data reduction, evaluation of elaborate integrals, solution of differential equations, matrix calculations and the like."[6]

Standard Oil Company (Ohio) is currently installing a large-scale computer. It will be used to study problems in "exploration, drilling, production methods, refinery operation, tanker and pipe line scheduling, truck routing, terminal throughput, station operation, market analysis, research and even human relations."[7] The company has had a number of medium-scale computers in use for several years calculating catalytic reformer gas plant equilibrium, mass spectrometer readings to yield mol percent, liquid percent of composition, gross Btu per cu. ft, b/d per 1000 cu. ft. of component, critical temperature and critical pressure.

Esso Standard Oil Company progressed through larger and larger computers in order to have equipment available both to accounting and technical departments.[8] This company used a large-scale computer in the New York service bureau to simulate the operation of a fluid catalytic cracking plant; this problem was followed by a complete refinery simulation model.

The Research and Development division of Sun Oil Company is utilizing an inexpensive computer for refinery performance calculations.

Another type of medium-scaled computer has been used to solve blending and cost problems in a non-linear petro-chemical application. The machine takes into account such factors as limiting vapor pressure, effects of adding catalyst polymer to different base stocks, required octane number of output and different results of adding tetraethyl lead to various base stocks.

Lee A. Whitney, vice president of Champlin Refining Company, reports that they are completely determining the levels of operation at minimum costs and maximum efficiency for two of the most important units, the reformer and the cat cracker. The company expects to use its computer on the following problems:

1. Scheduling deliveries for the pipe line.
2. Calculating the mass spectrometer problems daily.
3. Doing reservoir problems
4. Doing deliverability studies
5. Doing production gas-oil ratio forecasting
6. Estimates of recoverable oil
7. Studies of effects of gas injection
8. Studies of effects of water flooding."[9]

The entire chemical engineering field has awakened to computer possibilities. At the 119th meeting of the American Chemical Society in Boston, Mass., (1951) various applications of electronic computers in chemical engineering were considered; the subject has been under continuous study by the Society ever since. Typical papers have dealt with calculations of equilibrium gas compositions; equations of state constants used in predicting the volumetric and phase behaviour of multi-component mixtures of the lighter hydrocarbons; absorption calculations; batch distillation curves; performance factors of fuel-oxidant mixtures; solution of diffusion problems etc.

As an example of a practical situation, let us consider the blending of fuel oil for maximum profit. Here is a problem in linear programming which could readily be placed upon an electronic computer.

Similarly, a running plan for a refinery could be worked out, using a number of different crudes to yield a number of different products.

The term "linear programming" is being used more and more in management planning; indicative of its potential significance, FORTUNE MAGAZINE for February, 1956, carried an article entitled "Use of Linear Programming for Operations Research." An electronic computer is not indispensable in linear programming, but the plain fact is that most companies refrain from tackling the labor involved in a complex problem unless a computer is available, either in the company or on a service bureau basis.

Within the last year, one large manufacturer has produced a computer with huge capacity for storage of information. It utilizes the "juke box" principle with information stored magnetically on records, so providing a rapid access. This innovation holds promise to any refiner for multi-purpose applications of the computer.

Future Unlimited. Some of the papers presented at the Refining division meeting of API in Montreal, May 14-17, 1956, bear further testimony as to the growing importance of computers in refinery management:

"The Use of Computers in Petroleum Refinery Problems" by Jack Sherman, The Texas Co. Houston.

"The Design of Heat Exchangers on Automatic Computing Equipment" by A. M. Peiser, The M. W. Kellogg Co., Jersey City, N. J.

"Computers in Refinery Planning" by Robert G. Donovan and Robert W. Schrage, Esso Standard Oil Company, Linden, N. J.

"Calculation of the Equilibrium Composition in C_6 Hydrocarbon-Hydrogen Systems" by Edward B. Weinberger and C. W. Montgomery, Gulf Research and Development Co., Pittsburgh, Penn.

"Growth of a Technical Computing Activity" by T. H. Green, Jr., Shell Oil Co., Houston, Texas and C. M. Jones, Shell Oil Co., New York, N. Y.

"Solution of Multicomponent Distillation Problems on a Stored Program Computer" by J. S. Bonner, Humble Oil and Refining Co., Baytown, Texas.

Computers now at work in solving refinery problems vary from about $900 to $33,000 per month, with less expensive and more expensive, hardware on the horizon. Now is not too soon for every refining company, large or small, to master this new management-decision aid.

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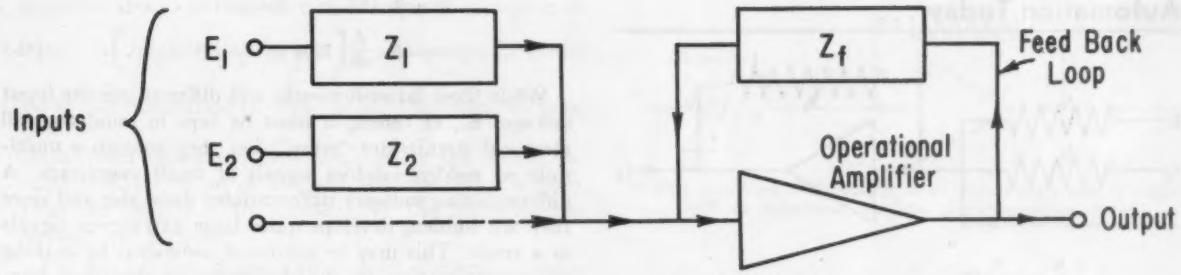

FIGURE 64—The design of the electronic differential analyzer is based on the "operational amplifier".

Part 12

Automation Today

Here is a review showing how various components of a computer simulate mathematical equations.

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Monsanto Chemical Company, St. Louis

AS A CONTINUATION OF our discussion of the computer simulation of processes which we began in the last part of this series, let us describe here how one uses the analog computer in carrying out the mathematical operations involved in process control simulation.

We wish, also, to describe the main types of computer components, their functions in problem solution, and how they may be connected together to represent certain mathematical relationships. Particular attention will be paid to those components needed in simulating the heat exchanger of Part 9 which will be used as an example of analog computer use. This will be covered in a subsequent part of this series.

The Analog Computer and Its Component Parts For Linear Equations. The most common type of analog computer in use today is the electronic differential analyzer which is commercially produced by several manufacturers. It is this machine which will be described here.

The electronic differential analyzer is based in its design and operation on the operational amplifier. This is a very high gain d.c. electronic amplifier whose properties can be modified by the addition of appropriate input and feedback electric elements. Thus the output voltage from this amplifier can be made to represent accurately certain desired mathematical functions of the input voltage or voltages.

Figure 64 diagrams how the operational amplifier and its associated input and feedback elements are connected together in order to carry out this property of mathematical representation or simulation. If the gain of the amplifier is very large (greater than 10^6), then the electronic circuit equation for the voltages in the circuit of Figure 64 is (2)

$$E_o = -Z_f \left[\frac{E_1}{Z_1} + \frac{E_2}{Z_2} + \ldots \right]. \qquad (1)$$

Here the Z's are the impedances of the elements, and various representations for them will be given herein. In case these elements are pure resistances, the circuit becomes as in Figure 65 and the equation assumes the form

$$E_o = -R_f \left[\frac{E_1}{R_1} + \frac{E_2}{R_2} + \ldots \right]. \qquad (2a)$$

Since the term R_f/R_1 can have any desired value, we have effectively multiplied the input voltage E_1 by a constant to obtain E_o. In addition, because there can be several inputs we also can form a simple adder by letting $R_1 = R_2 = \ldots = R_f$. Thus

$$E_o = -(E_1 + E_2 + \ldots). \qquad (2b)$$

Different values of R_f/R_1 with its resulting combination of additions and multiplication by constants can be expressed as

$$E_o = -(n_1E_1 + n_2E_2 + \ldots). \qquad (2c)$$

If the symbol of the dependent variable of the problem which is represented by the problem voltage is used in the above expressions, Equation 2c could appear as:

$$X_o = -(n_1X_1 + n_2X_2 + \ldots). \qquad (2d)$$

Figure 65 expresses this latter possibility and shows how the values of n are shown on the problem diagram.

If the feedback element is made a condenser with a capacitance of C_f farads, then

$$Z_f = Z_c = \frac{1}{C_f p} = \frac{1}{C_f} \int dt, \qquad (3a)$$

where p is the differential operator, $\frac{d}{dt}$, as discussed in Part 2. Thus we have formed an integrating network and

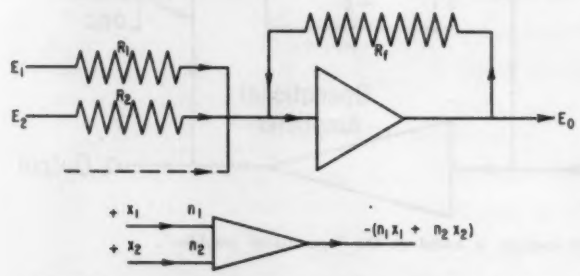

FIGURE 65—Different values of R_f/R_2 will give a system for addition and multiplication by constants.

$$E_o = -\frac{1}{C_f}\int\left[\frac{E_1}{R_1}+\frac{E_2}{R_2}+ \ldots \ldots\right]dt. \qquad (3b)$$

Figure 66 diagrams this arrangement.

Because the value of the term $\frac{1}{C_fR_1}$ can also have different values as does the term R_f/R_1, we have the possibility of changing the rate of integration as follows:

$$E_o = -\frac{1}{C_fR_1}\int E_1 dt - \frac{1}{C_fR_2}\int E_2\, dt - \ldots \ldots, \text{ or}$$

$$x_o = -[n_1\int x_1\, dt + n_2\int x_2\, dt + \ldots .]. \qquad (3c)$$

Since

$$Z_L = Lp = L\frac{d}{dt}$$

for an inductance, then such an element in the feedback loop would, in contrast to Equation 3, give us a differentiating network and thus

$$E_o = -Lp\left[\frac{E_1}{R_1} \quad \frac{E_2}{R_2}+ \ldots \ldots\right],$$

$$= -L\frac{d}{dt}\left[\frac{E_1}{R_1}+\frac{E_2}{R_2}+ \ldots \ldots\right]. \qquad (4a)$$

See Figure 67.

Similarly, differentiation may be obtained in theory by reversing the positions of the elements of Figure 66 as in Figure 68. Now with the capacitor in the input rather than in the feedback path Equation 1 becomes

$$E_o = -R_f\left[\frac{E_1}{\frac{1}{C_1p}}+\frac{E_2}{\frac{1}{C_2p}}+ \ldots \ldots\right],$$

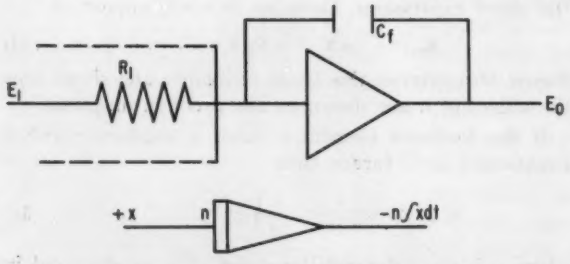

FIGURE 66—The rate of integration is established by the selection of capacitance and resistance.

$$= -R_f\,[E_1C_1p + E_2C_2p + \ldots .],$$

$$= -R_f\frac{d}{dt}\left[E_1C_1 + E_2C_2 + \ldots .\right]. \qquad (4b)$$

While these latter networks will differentiate the input voltages E_1, et cetera, it must be kept in mind that all electrical circuits are "noisy"; i.e., they contain a multitude of sudden random signals of small magnitude. A differentiating network differentiates these also and since they are sudden, develops quite large extraneous signals as a result. This may be corrected somewhat by making an approximation to the derivative as described elsewhere.[2,3,5]

A much more satisfactory procedure is to avoid the necessity for differentiation as much as possible. This can be done by making integration rather than differentiation the basis of our calculation procedure. For example, the general form of a typical ordinary differential equation might be written as

$$a\frac{d^2x}{dt^2} + b\frac{dx}{dt} + c\,x = F\,(t). \qquad (5)$$

To solve it in its given form would require the determination of at least one of the higher order derivatives of x. This, as we stated above, would result in the introduction of extraneous signals into the computation due to the noise normally present in an electronic circuit. If, however, we rearrange the equation to read

$$\frac{d^2x}{dt^2} = -\frac{b}{a}\frac{dx}{dt} - \frac{c}{a}x + \frac{F(t)}{a} \qquad (6)$$

and if we further assume that for the moment we know the value of $\frac{d^2x}{dt^2}$, the computer will permit us to solve the problem by a sort of "pulling one's self up by one's bootstraps" procedure.

Figure 69 is a diagram of the machine setup necessary to solve Equation 6. If we know $\frac{d^2x}{dt^2}$, then by integration we obtain $-\frac{dx}{dt}$ as given in Equation 3. Integration of this latter will then give us $+x$.

Now Equation 6 shows that $\frac{d^2x}{dt^2}$ is the negative sum of each of the other terms, each multiplied by its constant divided by a, plus the forcing function, $F(t)$, also divided by a.

By means of a lead from the output of each integrator we can thus form the above sum at the input of the first integrator of Figure 69 and therefore obtain the only factor lacking in our solution.

The presence of the constants $\frac{c}{a}$, and $\frac{b}{a}$ brings up the need for another device which is an invaluable component of the computer. This is the potentiometer or voltage divider which permits multiplication by any constant with a value less than 1.0.

In case the value of $\frac{b}{a}$ or $\frac{c}{a}$ is greater than 1.0, we can choose the proper value of $R_f/R_1 = n$ such that the $\frac{b/a}{n}$ is a number we can set on our potentiometer. Normally the computer has a built-in choice of several values of n for use in such situations.

Notice, also, that due to the fact that an operational

amplifier always delivers an output opposite in sign to its input, the quantity $\left(\frac{c}{a}\right)x$ has the wrong sign for direct use in our summation to obtain $\frac{d^2x}{dt^2}$. Therefore, we must use a "sign changer." This is an adder for which the value of R_f/R_1 is set at 1.0, and only one input is used. Thus the output is the negative of the input accomplishing our purpose.

For the solution of any second-order differential equation two constants must normally be specified. In the case of the electronic differential analyzer this is accomplished by specifying the initial values of the dependent variable and each of its derivatives other than the highest one. This is accomplished in the computer by establishing the voltages present in each of the integrators at zero time or the beginning of the calculation. This is indicated in Figure 69 by the arrows entering the integrators from the top and labeled as "initial $\frac{dx}{dt}$" or "initial —x."

Every electronic differential analyzer is a collection of a certain number of each of the components listed above and those to be described below, the particular number of each depending upon the specific needs of the purchaser. Each of these components has its input and output leads connected to a set of plug jacks at some central location in the machine. It is then possible to connect these plug jacks together with external leads to connect the computer components together in the configuration desired for the problem at hand. Figure 69 indicates which is internal and which is external wiring for the second order equation considered here.

With the definition of these computer components: adders, sign changers, integrators, and potentiometers, we have all the necessary components for the solution of linear equations. These are cases where the dependent variable is not multiplied by itself or by any of its derivatives.

Time and Magnitude Scaling. As we stated in Part 11, the main use of the analog computer is in process simulation or the facility of causing the computer to behave like the process in such a manner that voltage in the computer varies in the same way as the dependent variable of the process for an equivalent disturbance. However, computing voltages in the computer are usually limited to ± 100 volts. In addition, the values of R_f and C_f that are picked for the integrators determine the time constants and, therefore, the frequency of oscillation of the electronic circuit of Figure 69 and Equations 5 and 6.

It is therefore necessary to determine the maximum value which the dependent variable of our process in question can attain with the conditions under study. The texts on analog computers[2,3] and on servomechanisms[1,4] give several short cut methods for determining this maximum magnitude and also the probable frequency of oscillation of the system if they cannot readily be attained from physical considerations. We do not have space to detail these short cut methods here.

We then let this determined maximum magnitude be represented by 100 volts. We thus develop a factor by

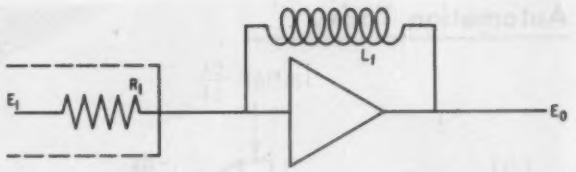

FIGURE 67—When the capacitor of an integrating circuit is replaced with an inductance, we have a differentiating circuit.

which the computer voltages may be converted to values of the process variable. For example, if we were investigating a fluid flow process with flow rate as the dependent variable, and if the maximum flow rate was 540 pounds of fluid per minute, the factor will be as follows:

$$1 \text{ volt} = \frac{540 \text{ pounds per minute}}{100} = 5.40 \text{ pounds per minute} = S_x \tag{7}$$

We now convert our original differential equation, expressed in flow units, to another expressed in volts by dividing each of the terms of our original differential equation by the factor just derived. We now have an equation whose variable is in units of volts, the magnitude of which never exceeds 100.

In addition to the natural frequency of any computer setup due to the time constants of the integrating networks, the differential analyzer also has an upper frequency limitation due to the characteristics of most recorders and some multiplying equipment at about 50 cycles per second. It also has a lower limit of about one cycle in five to ten minutes due to the accumulation of errors and to drift in the integrators.

Since some physical situations which we wish to simulate are far faster than this (some vibrating mechanical systems) and others are far slower (some large scale chemical processes), we must adjust our differential equation to match the capabilities of our computer. This is done by defining a time scale change; i.e., a new time variable, τ, which converts the natural time variable of the process being simulated to one which is compatible with the computer. Thus, if $\frac{\tau}{S_t} = t$

$$\frac{d}{dt} = \frac{d}{d\left(\frac{\tau}{S_t}\right)} = S_t \frac{d}{d\tau}, \text{ and}$$

$$\frac{d^n}{dt^n} = (S_t)^n \frac{d^n}{d\tau^n} \tag{8}$$

Equation 5 with both magnitude and time scale changes applied now appears as

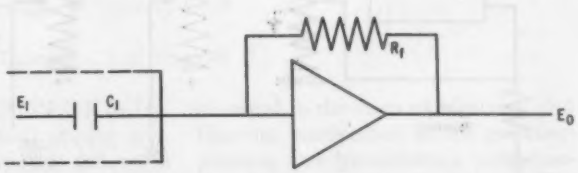

FIGURE 68—Another way to form a differentiating circuit is to change the position of the capacitor.

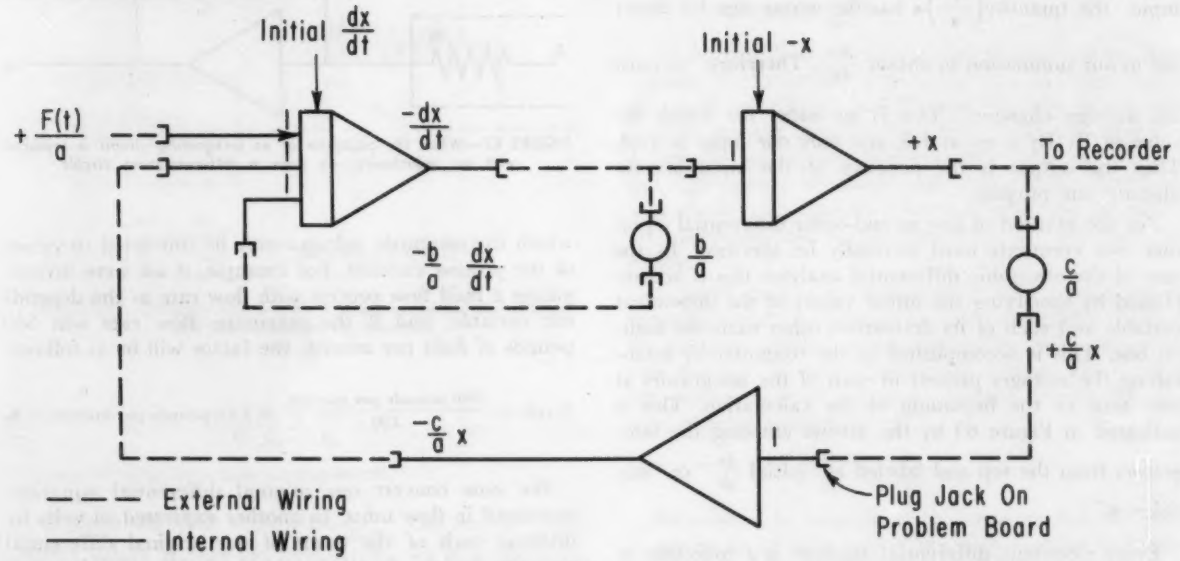

FIGURE 69—To avoid the effect of "noise" in a differentiating circuit, it is better to rearrange the form of the equation so that integration may be used.

$$\frac{(S_t)^2}{S_x}\,a\,\frac{d^2x}{d\tau^2}+\frac{S_t}{S_x}\,b\,\frac{dx}{d\tau}+\frac{c}{S_x}x=\frac{1}{S_x}\,F\left(\frac{\tau}{S_t}\right) \quad (9)$$

If, for example, the actual physical system were twice as fast as the computer limitations would allow, we must slow the problem down by a factor of 2, and we would let $S_t = 2$.

Nonlinear Functions. We now have the facility to solve any linear differential equation. The extension of our capabilities to include nonlinear equations is made possible by the addition of multiplying and function generation equipment to the computer components. Because process systems are nearly always nonlinear, these latter components are an absolute necessity in computers procured to investigate these systems.

Figure 70 illustrates how a typical multiplier, the servomultiplier, accomplishes its task. x_1, the first variable, causes the servo to position the brushs of a series of potentiometers at that fraction of their total travel.

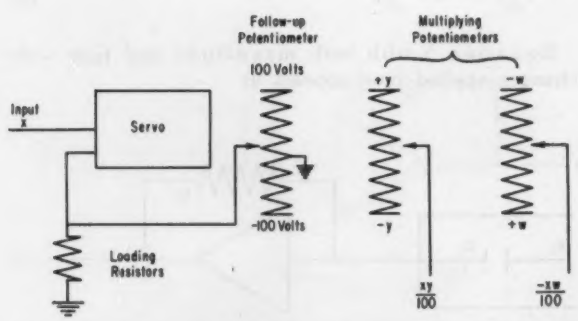

FIGURE 70—The servomultiplier is a valuable tool for carrying out multiplication and division by a variable.

If now the voltage represented by a second variable, x_2, is imposed upon the windings of one of the potentiometers, an output taken at the brush will be proportional to x_1x_2, in this case $\frac{x_1x_2}{100}$.

The servomultiplier can also be a vital tool in carrying out another important arithmetic operation, that of division by a variable. However, in the interest of space in this paper, a complete discussion of this topic will be left to the texts on analog computers[2,3] since division by a variable is not involved in our simple calculation, the heat exchanger of Part 9.

In addition to the servomultiplier just described, most of the manufacturers also produce an all-electronic multiplier. The electronic multiplier has a higher frequency limitation than the servomultiplier but is usually more expensive and somewhat less accurate.

When the physical situation described by the set of nonlinear differential equations being simulated requires the production of functions more complex than is possible with any of the equipment mentioned above, the use of function generators is needed. These are groups of relays, of diodes, of variable resistance potentiometers, and other devices, either singly or in combination.

The resulting networks can readily form such functions as limits, exponentials, jump functions, and other arbitrary functions as desired. Again space forces us to direct the reader to the texts.[2,3]

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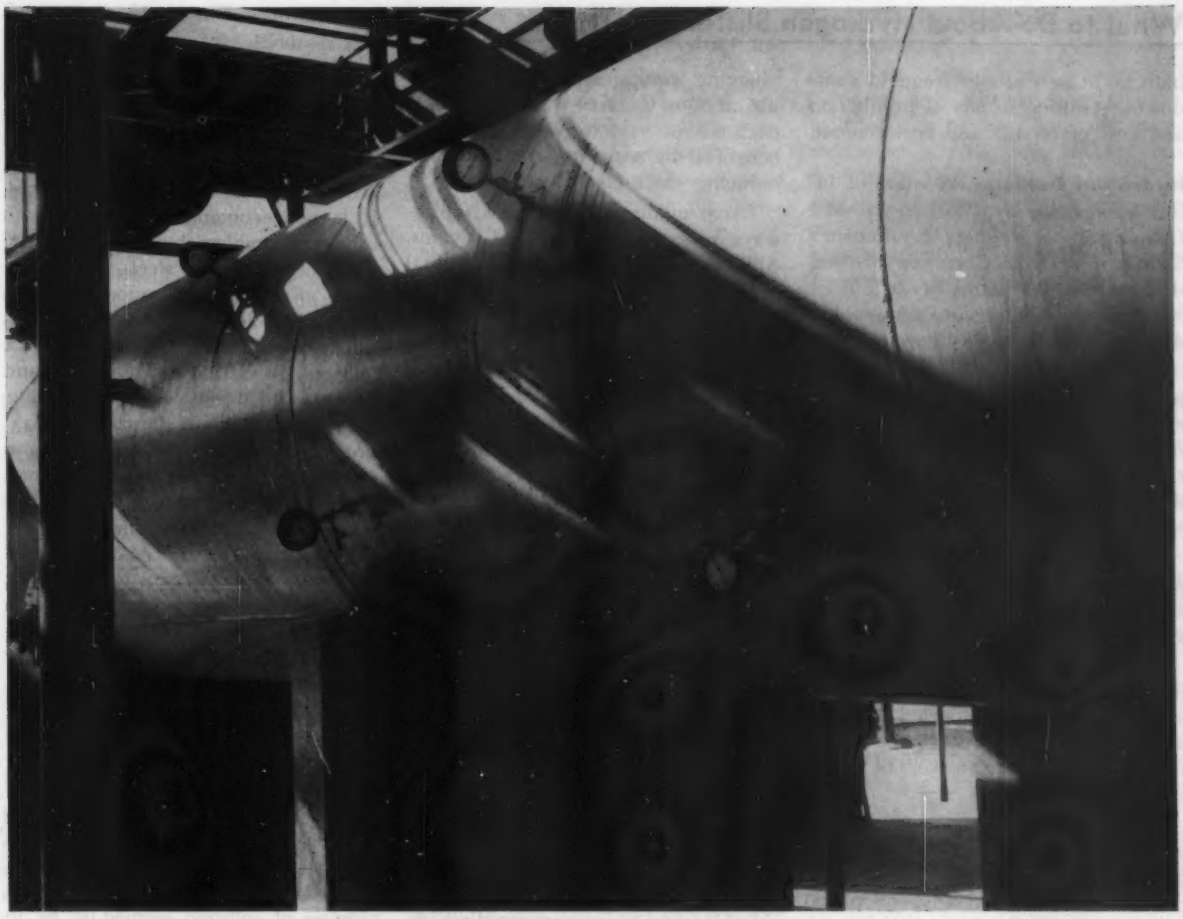

FIGURE 1—Hydrogen probes detect hydrogen penetration in case H_2S removal and water wash are not adequate.

What to Do About Hydrogen Blistering

Here's how Richfield tackled the problem of hydrogen blistering in their fluid catalytic cracking unit.

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C. M. Schillmoller
International Nickel Company, Los Angeles

THE PHENOMENON OF hydrogen penetration of steel, causing serious weakness and eventual failure, is now well recognized. Extensive damage to refinery equipment has been observed in the form of blistering and fissuring, particularly in the gas compression and fractionating units associated with catalytic cracking.[1,2] The cost of this type of corrosion is very

high, as it necessitates frequent shutdowns, resulting in loss of production and cost of repairs and replacement.

Hydrogen Damage. A study of information made available to the API Committee on Refinery Equipment's Subcommittee on Corrosion showed that, in the gas plants of 26 out of 38 fluid units, 72 occurrences of hydrogen blistering were discovered.

The stabilization section of the gas plant appeared to be the most vulnerable to hydrogen attack. Of the 72 occurrences found, half are located in the overhead equipment of the debutanizer, depropanizer and deethanizer.

The next most frequent occurrence, 25 instances, was in the coolers and accumulator equipment following the gas compressors.

In nine instances, hydrogen blistering was found in the gas absorber; and only two units reported damage as early in the system as the main fractionator accumulator or its water knock-out pot.

It can be said that the active environment follows the light hydrocarbons throughout the gas plant. The pattern of damage in any one plant is erratic. For example, one condenser may show damage while the one in parallel will not. The attack is generally more severe in the vapor phase than in the liquid hydrocarbon or aqueous phases.

Corrosive Environment. At all these fluid unit locations there is a free-water phase, a high sulfide concentration, a high pH value, and the presence of cyanides and organic acids.

An aqueous phase is of course essential, inasmuch as the hydrogen which penetrates the steel is a product of the electrolytic corrosion cell. Large quantities of steam are introduced at the reactor and main fractionator unit, most of which is withdrawn as water at the fractionator overhead accumulator. However, considerable quantities are carried forward to the gas plant and possess high concentrations of acidic constituents.

Some refineries apply water washes to prevent water-soluble salts, such as ammonium chlorides at the top of the main fractionator and ammonium thiocyanates at the absorber, from plugging equipment. These contribute also to the free-water phase. As disclosed later, waterwashing can be beneficial by removing chemicals and reducing their concentrations.

Large quantities of sulfides are always present in the fluid-unit streams. Apparently the sulfides play a dual role, viz., that of a corrosive constituent and that of a promotor. Hydrogen-penetration rates increase with the partial pressure of the sulfides, and these are normally high in the high-pressure towers of the gas plant.

The pH values of the different waterdraws are mostly in the alkaline range—7.5 to 9.2—because of the large quantities of ammonia formed in the cracking process from the nitrogen compounds in the oil charge. This ammonia accounts for the low corrosion rates of the steel, despite the high concentrations of sulfides and other acidic components.

It should be pointed out that high corrosion rates are not necessary for hydrogen blistering to occur; blisters at corrosion rates of 0.001 in. per year have been reported.[3,4] The pH of the system very much influences the rate of hydrogen attack. Penetration rates were found to practically cease at a pH of 7.5 and to increase rapidly with lower and higher pH values.[4,6]

The cyanides have shown a marked effect on hydrogen penetration rates in alkaline solutions. The ferrous-sulfide coating, which normally slows the corrosion reaction down to a fraction of its original rate, was observed to dissolve with the formation of ferro cyanide complexes. This modifies the scale so as to permit the corrosion reaction to continue. The aliphatic acids and other organic acids contribute to this scavenging action, but are generally more apparent in acidic solutions. Hydrogen blistering may be expected when the organic nitrogen compounds in the fresh feed to the fluid unit exceed 0.05 percent by weight.[7] Some of this nitrogen forms ammonia and cyanides in the cracking process and supplies a promoter chemical in a high pH system.

Stop Hydrogen Penetration. Any one of the standard weapons against corrosion can be used:

- A change of environment or of the process to make it less corrosive.
- The use of more corrosion-resistant materials.
- A barrier between the corrosive fluid and the base metal.

Because low-carbon steel is commonly utilized in the construction of refinery process equipment and pipes, it is not economically justifiable to solve the problem by changes in the metallurgy of the steel. Alloys are quite effective if corrosion is halted completely. However, if a slow corrosion rate continues, hydrogen attack may still prevail. Monel, types 304 and 316 stainless steel (solid or clad) have been used to avoid damage. Utilization of alloys is more of a stop-gap measure at particular vessel locations, and is usually too expensive for interconnecting piping and the like.

Organic protective coatings based on epon and vinyl resins have in some cases been effective. Cement linings can be very good in places like sour-water strippers or diethanolamine strippers, but are not practical for all vessels and interconnecting piping.

Corrosion inhibitors are fairly specific, and can be useful in particular cases. Minute amounts of the proper chemical added to the process stream may effectively stop corrosion and greatly extend the life of equipment.

To Richfield engineers, the greatest promise of solution seemed to be in changing the environmental conditions, so as to permit the use of ordinary grades of low-carbon steel. Elimination of most of the corrodents and reduction of their concentrations to a tolerable level, are the most effective ways to solve this problem.

The study of process conditions under which blistering has occurred provide the following clues to a remedy for hydrogen attack:

- Remove hydrogen sulfide
- Reduce the organic-acid concentration
- Convert the cyanide promoter to thiocyanate
- Dry the process stream
- Neutralize the stream to a pH of 7.5

Several of these adjustments are being applied concurrently by Richfield to assure effectiveness since a complete removal of hydrogen sulfide, organic acids, cyanides or water is not practical.

Protective Steps. The two major protective steps incorporated in the design of the fluid-unit gas plant were based on changes in environment created by: (1) early removal of hydrogen sulfide; and (2) extensive water-washing starting at the fractionator overhead system.

Allowance was made to detect hydrogen penetration in an early stage if it should occur, and sufficient flexibility has been provided to reduce hydrogen activity to a low level if the need arises.

Early Removal of H_2S. Hydrogen sulfide is removed for the following reasons:

a. To protect the system from hydrogen attack and corrosion in general.
b. To minimize the sulfur content of refinery gas to comply with the air-pollution regulations.
c. To eliminate sulfur in the polymerization feed.
d. To reduce the possibility of sulfide-hydrate formation in the refrigerated de-ethanizer condenser.

These could be best accomplished by locating the hydrogen-sulfide absorbers ahead of the high-pressure section of the gas plant. Here, a diethanolamine solution is employed for the absorption of hydrogen sulfide in the vapor-phase and liquid-phase hydrogen-sulfide absorbers. The rich solutions are fed to a common diethanolamine regenerator tower where the hydrogen-sulfide gases are stripped and sent to a sulfur-recovery unit. Both absorbers are designed for 99½ percent hydrogen sulfide removal.

A caustic wash was installed ahead of the de-ethanizer to remove mercaptans and insure a sulfur-free polymerization feed. The caustic wash also provides momentary protection against short-period failures of the diethanolamine system. By following the caustic wash with a drier, an additional safeguard is obtained against hydrate formation in the refrigerated de-ethanizer condenser. This also prevents water from freezing out.

By this procedure, the sulfides and free-water phase are reduced to a minimum in the de-ethanizer feed and, inasmuch as both are necessary components for hydrogen blistering to occur, ample protection is provided for the overhead equipment of the de-ethanizer and depropanizer.

Extensive Water-Washing. An extensive water wash is applied for the following reasons:

a. To remove a large part of the cyanides and aliphatic acids from the gas stream. These active promotors of hydrogen blistering are selectively extracted in the high-pH water phase. By doing so, the concentrations of these components are reduced to a safer level.
b. To reduce the concentration of acidic components in the water phase by dilution and, in that way, to alleviate hydrogen attack at the location of water wash.

Refineries have obtained the best results with water washing in cases where the water contained air. This gave the additional benefit of polysulfide formation which transformed cyanide into thiocyanate. In some instances, smaller water washes—e.g. to remove salt formations in the absorber—have invited hydrogen blistering to occur at that or the following vessel in the process stream.

Provisions were made for fresh-water wash of 150-gallons-per-minute capacity on the main fractionator overhead stream ahead of the condensers, and for a reclaim water wash of 100-gallons-per-minute capacity ahead of the first-stage compressors' aftercoolers. The fresh water is treated, free of suspended matter and does not contain calcium or magnesium (these can form salt deposits in condensers). Practically all oxygen is removed from the wash water in the lime treater. Unfortunately, no air-containing water can be used in Richfield's water-wash system, because the oxygen would contaminate the diethanolamine solution by formation of thiosulfates.

The steam to the reactor and main fractionator—which accounts for approximately 100 gallons per minute of condensate—does not contain oxygen either, inasmuch as the boiler feed is de-aerated. The reclaim water—which is the bottom from the water reclaimer—is free from sulfides, but contains a fairly high quantity of acidic components. For this reason the reclaim-water wash ahead of the first-stage compressors' after coolers was replaced by a fresh-water wash.

TABLE 1
Total Corrosive Constituents in Richfield's Fluid-Unit System

Constituents	FCC Main Fractionator Overhead Stream, Pounds Per Day	TCC & Thermal Units Extraneous Streams, Pounds Per Day	Total Constituents, Pounds Per Day
Ammonia	7,000	400	7,400
Sulfides	57,000	29,000	86,000
Carbonates	26,000	6,000	32,000
Cyanides and Thiocyanates	1,500	500	2,000
Phenols	7,000	100	7,100
Aliphatic Acids	5,500	1,000	6,500
Total	104,000	37,000	141,000

Evaluation of the Steps. To evaluate the steps taken to control corrosion at the fluid unit, analyses were carried out on all process streams throughout the unit for ammonia, cyanide, thiocyanate, sulfide, carbonate, phenol and aliphatic acid. Two series were taken—one without a water wash, and one with the maximum-design wash applied at both locations. The concentrations in the streams were converted to pounds per day of corrosive constituents, and the streams were balanced.

Inasmuch as the technique for cyanide determinations has not been well established due to the reactive nature of the cyanides, the cyanides and thiocyanates are grouped together in the following tables.

This balance showed that the total amount of corrosive constituents in the FCC main fractionator overhead stream and in the extraneous streams to the unit (TCC and thermal dry gas and debutanizer overhead) approximates 134,000 pounds per day. A breakdown of these components is given in Table 1. Ammonia is, of course, not corrosive, but was included in the tables for comparison, as it is beneficial in keeping corrosion rates down.

Of the 134,000 pounds per day of corrosive constituents in the system, roughly 30,000 are removed by the water, 88,000 by the diethanolamine solution, and only 16,000—that is 12 percent—reach the gas plant. Removal of the individual constituents is shown in Table 2, expressed in pounds per day and in percentage removal of the total quantity of constituents present in the system.

The sulfide removal by the diethanolamine solution is very good; concentrations are reduced from 43,360 ppm in the flash-drum vapor to 425 ppm in the feed to the second-stage compressors. This is further diluted to 50 ppm in the absorber-demethanizer when mixed with the liquid feed to this tower. The diethanolamine solu-

tion also extracts a large quantity of cyanides, thiocyanates, and aliphatic acids. This is beneficial from a corrosion or hydrogen blistering point of view, even if undesirable from the hydrogensulfide-removal angle. The early location of the absorbers aggravates contamination of the diethanolamine solution.

The total removal of acidic constituents in the water is good, even though the incremental removal due to the application of the extensive water wash is not as high as anticipated.

Table 3 shows the removal by the total water, the removal by the natural water in the system (condensate), and the removal by the applied water wash (obtained by difference). All constituents are expressed in pounds per day and in percentage removal of the quantity present in the main fractionator overhead stream.

No facilities for water-washing the extraneous TCC and thermal dry-gas streams are provided. These streams enter the top of the flash drum and contain over 31,000 pounds per day of corrosive constituents. This extraneous stream is not considered in the evaluation of the water wash in Table 3.

Table 3 shows that if no water wash is applied, the natural waters in the system remove 20 percent of the constituents, whereas a 250 gal-per-minute applied water wash removes an incremental 15 percent. These figures, based on a single series of analyses, indicate that the removal of corrosive constituents from a hydrocarbon stream by a water wash is not particularly effective. The benefit of water-washing to combat hydrogen blistering is seen more in the fact that the concentrations af acidic components in the water phase are reduced by dilution.

Monitoring Control. As part of the hydrogen-blistering control program, a system of 31 hydrogen probes was installed to detect hydrogen penetration at an early stage in case the hydrogen-sulfide removal and water wash were not adequate to protect the complete fluid-unit gas plant.

Hydrogen probes in key positions were either doubled or made accessible during operation. Figure 1 shows a typical installation of hydrogen probes in the hydrocarbon vapor and liquid phases at an overhead accumulator. Also one probe is located between valves in the water-draw line. All probes are being read twice weekly by one of the operators at the fluid unit, and the readings noted on a monthly probe sheet.

In addition to the probe readings, the laboratory carries out twice-weekly determinations of iron counts and pH values at all fluid-unit water draws, as well as frequent quantitative tests for cyanides and thiocyanates, applying a paper-chromatographic method. Occasional painted-can tests are taken.

All these routine checks make continuous corrosion control possible and will detect changes in environment immediately, so that protective steps can be taken when needed without waiting for visual inspection after damage has occurred.

Locations of Concentrated Corrosion Environment. With the protection of the high-pressure stabilization section of the fluid-unit gas plant by a hydrogen-sulfide removal and water-wash system, it was expected that severe corrosion would occur at the diethanolamine regenerator and at the water reclaimer, where most of the sulfides and other acidic salts are concentrated.

Control at the DEA Regenerator. Referring to Table 2, we see that approximately 64,200 lbs. per day of hydrogen sulfide and 21,500 lbs. per day of carbon dioxide are stripped out of the diethanolamine solution, along with fairly large quantities of cyanides, aliphatic acids and ammonia. These corrodents, in the presence of roughly one mole of water per mole of acid gas stripped, create a very potent solution.

Richfield's unit is constructed of carbon steel throughout with a ⅛-in. corrosion allowance, all welds being stress relieved. Provisions were allowed for injecting a corrosion inhibitor in the overhead line ahead of the regenerator condenser.

To evaluate the corrosion rate and hydrogen-penetration rate, a retractable hydrogen-probe, test-coupon assembly was installed (Figure 2). The assembly can be inserted through a valve into the stream during operation and periodically removed to determine the corrosion rate and for inspection of the probe.

The unit started up without the introduction of a corrosion inhibitor and, in the first 24 hours of operation, the probe pressure increased by 48 psi. Immediately, a filming amine inhibitor was introduced at a rate of three gallons per day while the equipment was clean, and probe activity was halted completely. The injection rate was then adjusted to two gallons per day to maintain a concentration of 50 ppm in the lean diethanolamine solution.

TABLE 2
Removal of Corrosive Constituents by Water and by Diethanolamine Solution

CONSTITUENTS	TOTAL CONSTITUENTS	REMOVED BY TOTAL WATER		ABSORBED BY DIETHANOLAMINE SOLUTION		BALANCE TO GAS PLANT	
	Pounds per Day	Pounds/ Day	Percent	Pounds/ Day	Percent	Pounds/ Day	Percent
Ammonia	7,400	6,300	85	700	10	400	5
Sulfides	86,000	21,100	24	64,200	75	700	1
Carbonates	32,000	4,000	12	21,500	67	6,500	20
Cyanides and Thiocyanates	2,000	1,000	50	400	20	600	30
Phenols	7,100	1,750	25	100	1	5,250	74
Aliphatic Acids	6,500	1,850	28	1,600	25	3,050	47
Total	141,000	36,000	25	88,500	63	16,500	12

TABLE 3
Removal of Corrosive Constituents by Applied Water-Wash

CONSTITUENTS	FCC MAIN FRACTIONATOR OVERHEAD STREAM	REMOVED BY TOTAL WATER		REMOVED BY NATURAL WATER		REMOVED BY APPLIED WATER	
	Pounds per Day	Pounds/ Day	Percent	Pounds/ Day	Percent	Pounds/ Day	Percent
Ammonia	7,000	6,300	90	4,300	61	2,000	29
Sulfides	57,000	21,100	37	11,200	20	9,900	17
Carbonates	26,000	4,000	15	2,500	9	1,500	6
Cyanides and Thiocyanates	1,500	1,000	67	550	37	450	30
Phenols	7,000	1,750	25	1,050	15	700	10
Aliphatic Acids	5,500	1,850	34	800	15	1,050	19
Total	104,000	36,000	35	20,400	20	15,600	15

Large quantities of cyanides and other acidic salts were found to recycle with the reflux water to the regenerator, and their concentrations in the overhead system tend to build up to a high level. A slipstream was taken of the regenerator reflux to limit the cyanide concentration here.

Iron counts in this unit have been at a satisfactory level and, the regenerator tower and the overhead equipment were in good condition when visually inspected.

Control at the Water Reclaimer. Waters drawn from the fractionator overhead accumulator and flash drum are fed to the water reclaimer to strip out the sulfides, permitting the disposal of water to the sewer system. Smaller quantities of water drawn from the absorber-demethanizer dehydrator, debutanizer accumulator, and diethanolamine regenerator reflux also feed into the water reclaimer.

The feed components to the unit are those indicated in Table 2, under "Removed by Total Water"; i.e., 6300 lbs. per day of ammonia and 29,700 lbs. per day of corrosive constituents. The pH of this sour water is about 9.2.

The water-reclaimer unit is constructed of carbon steel with a ¼-inch corrosion allowance on the tower. The overhead condenser is mounted directly on top of the tower in a fashion as shown in Figure 3, so that no overhead accumulator is required. The tower is equipped with 15 trays with bubble caps. No alloys are employed.

Four hydrogen probes were installed in this system: one in the vapor outlet line past the condenser; two in the manhole cover in the top of the tower in the vapor phase; and one in the liquid phase positioned between the bubble caps on the top tray, where the most corrosive medium is expected.

Facilities were provided to inject a corrosion inhibitor into the short connection between the tower and the condenser. Note in Figure 3 how a pitot-shaped ¼-inch tube is used, curved upward in the middle of the vapor stream to invite entrainment of some of the nonvolatile inhibitor for protection of the condenser. A duplex pumping unit of adjustable capacity is used for the continuous inhibitor injection.

No corrosion inhibitor was used in the initial operation of this unit. Iron counts taken on the sour-water feed and the reclaimer tower bottoms indicated a high rate of corrosion. Occasional probe activity showed on the probes in the vapor phase of the tower, and steady increases of several pounds a day showed at the vapor outlet probe. The painted-can test showed positive on the sour-water feed to the tower.

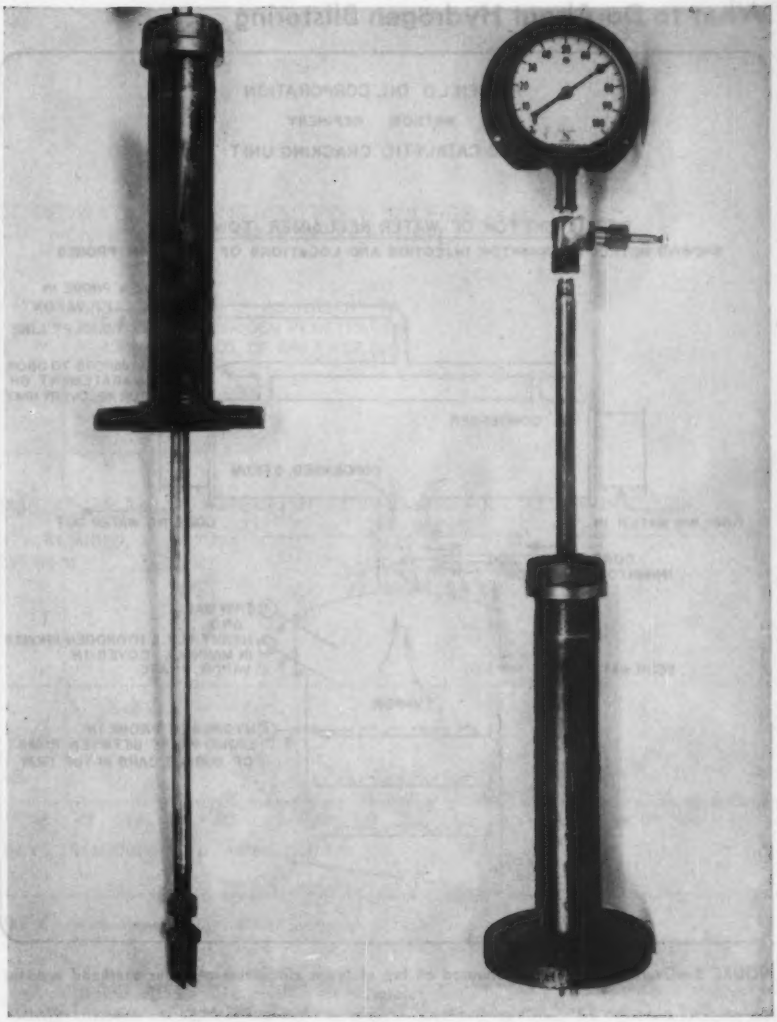

FIGURE 2—Retractable hydrogen-probe and test coupon assembly evaluate the corrosion rate.

After one month of operation, a filming amine type of corrosion inhibitor was injected at a rate of six gallons per day to maintain an inhibitor concentration in the tower of 12 to 16 ppm. This has been found effective in lowering the iron counts and in stopping probe activity, even in the vapor outlet line.

Because of the high pH of the sour-water feed (9.2), only 90 percent to 96 percent of the sulfide could be stripped, and the reclaimer-bottom sulfide content was too high to be disposed of in the refinery sewer system. This was solved by sulfuric-acid injection into the sour-water feed line. A high-silica iron section with mixer is employed here with a continuous pH control at 7.3. The acid injection, neutralizing the sour-water feed, is also beneficial from a corrosion and hydrogen blistering angle.

Painted-can tests on the neutralized water show negative, whereas those ahead of the acid-addition point cause big blisters under the paint. This confirms Shell Oil Company's experience that a minimum hydrogen penetration rate is found at a pH of around 7.3.[4,6]

Iron counts have been negligible since the introduction of the corrosion inhibitor. Also, the tower and over-

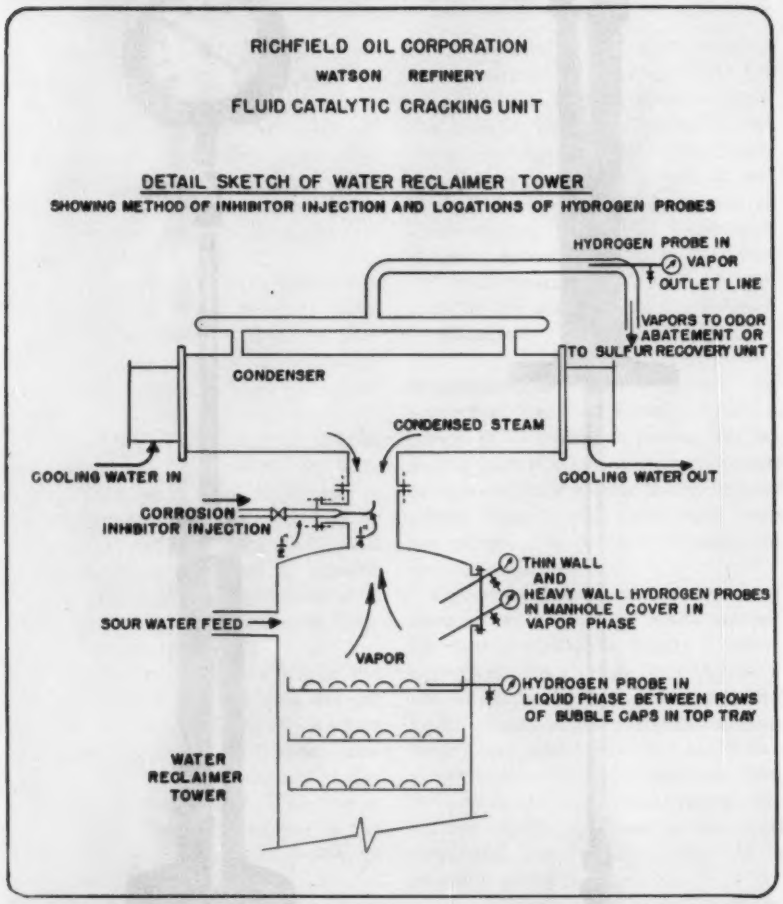
RICHFIELD OIL CORPORATION
WATSON REFINERY
FLUID CATALYTIC CRACKING UNIT
DETAIL SKETCH OF WATER RECLAIMER TOWER
SHOWING METHOD OF INHIBITOR INJECTION AND LOCATIONS OF HYDROGEN PROBES
HYDROGEN PROBE IN VAPOR OUTLET LINE
VAPORS TO ODOR ABATEMENT OR TO SULFUR RECOVERY UNIT
CONDENSER
CONDENSED STEAM
COOLING WATER IN
COOLING WATER OUT
CORROSION INHIBITOR INJECTION
THIN WALL AND HEAVY WALL HYDROGEN PROBES IN MANHOLE COVER IN VAPOR PHASE
SOUR WATER FEED
VAPOR
HYDROGEN PROBE IN LIQUID PHASE BETWEEN ROWS OF BUBBLE CAPS IN TOP TRAY
WATER RECLAIMER TOWER

FIGURE 3—Overhead condenser mounted on top of tower eliminates need for overhead accumulator.

head condenser were in good condition when visually inspected.

Polysulfides on Standby. At Richfield's fluid unit, provisions were made to inject polysulfide into the water-wash streams at the main fractionator overhead stream ahead of the condensers and ahead of the first-stage compressors' aftercoolers. Also, provisions were made to inject an organic corrosion inhibitor into the primary lean oil stream to the absorber-demethanizer and into the debutanizer overhead line ahead of the condensers. These facilities were on standby, to be used when experience dictated the need.

Early last year there was occasion to apply polysulfide-injection ahead of the first-stage compressors' aftercoolers:

The water-reclaimer overhead gases contain large quantities of sulfides, which were originally burned in the odor-abatement furnace, causing sulfur dioxide concentrations in the fuel gases that were higher than desirable. To overcome this, it was decided to route the reclaimer overhead gases to the main fractionator accumulator so that the hydrogen sulfide could be absorbed in the fluid-unit diethanolamine contactor. This to be done as a temporary measure until a separate diethanolamine contractor could be built.

The effects were immediate: iron-counts in the flash drum water-draw doubled and ferrocyanides appeared in this water. Analysis of streams showed a 22 percent increase of sulfides in the first-stage compressors' aftercoolers and flash drum and, also, a considerable increase in the cyanide concentration (as high as 1200 ppm in the flash drum water-draw). At that time, the water-washing facilities did not operate, awaiting the installation of a fresh treated-water connecting line. Concern was expressed, but no action was taken because the hydrogen probes in that system were not active.

Two months later hydrogen probe activity showed at the first-stage compressors' aftercoolers. Probe increases were 26 pounds per day, sufficiently high to cause severe damage in a short period if slag inclusions or small laminations were present in the steel. The probe activity is shown in Figure 4, plotted as daily pressure increases against calendar days.

After six days of high activity, the penetration was reduced by 85 percent by introducing a 25 barrel-per-hour water-wash. After eleven more days, the system was brought under complete control by injecting 12 gal. per day of sodium polysulfide. Probe activity stopped, iron counts were reduced from 40 ppm to 2.5 ppm and filter-paper spot tests showed a complete disappearance of ferrocyanides. Free cyanides are still present at about 100 ppm concentration. The pH of the water drawn from the flash drum is about 8.2.

This is interpreted as follows:

If cyanides are present in high concentrations in an alkaline medium, they react with the ferrous sulfide coating on the vessel walls and scavenge this coating off the vessel wall, permitting the hydrogen sulfide attack on the steel to continue. This results in a continued hydrogen penetration. Ferrocyanides show up in the water-draw when this happens.

Polysulfides behave as a chemical inhibitor. In an irreversible process they react with the corrosion product, ferrous sulfide, to form an iron polysulfide film on the steel. This film will be stable if the cyanides are at a low enough concentration.

In Richfield's system, there are approximately 1000 pounds per day of cyanides in the aftercoolers and flash drum. In this case, it is not practical, nor desirable, to react these cyanides with polysulfides to thiocyanates. The solution had to be found in diluting the cyanides in the water phase to a low concentration (about 100 ppm) by water-washing, so that only a small amount of polysulfide is required to act as a chemical inhibitor.

That only a small amount is required, is apparent in our cases where only 12 gallons per day of sodium

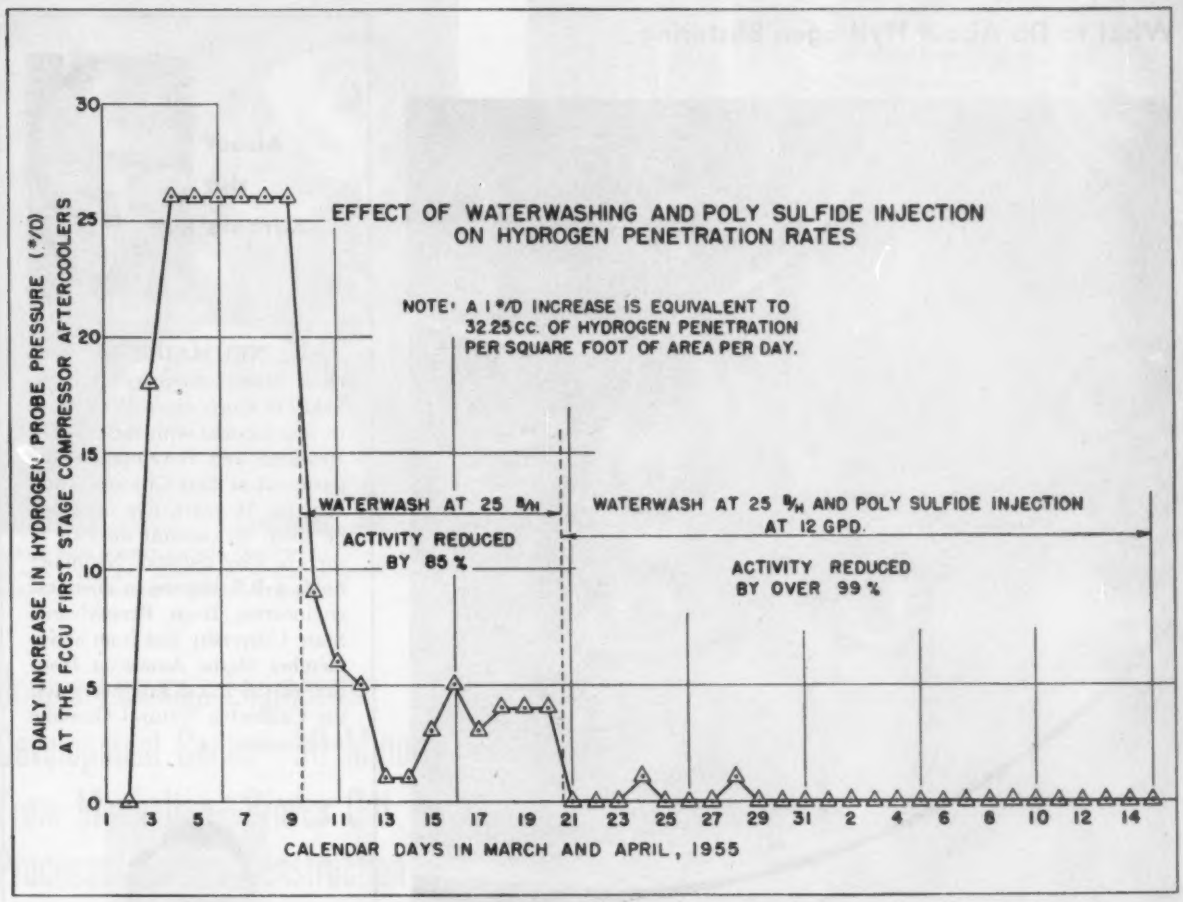
EFFECT OF WATERWASHING AND POLY SULFIDE INJECTION
ON HYDROGEN PENETRATION RATES
NOTE: A 1 #/D INCREASE IS EQUIVALENT TO
32.25 CC. OF HYDROGEN PENETRATION
PER SQUARE FOOT OF AREA PER DAY.
WATERWASH AT 25 #/H
ACTIVITY REDUCED
BY 85 %
WATERWASH AT 25 #/H AND POLY SULFIDE INJECTION
AT 12 GPD.
ACTIVITY REDUCED
BY OVER 99 %
DAILY INCREASE IN HYDROGEN PROBE PRESSURE (#/D)
AT THE FCCU FIRST STAGE COMPRESSOR AFTERCOOLERS
0
5
10
15
20
25
30
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 2 4 6 8 10 12 14
CALENDAR DAYS IN MARCH AND APRIL, 1955

FIGURE 4—Probe activity shows effect of water washing.

polysulfide solution was injected. This contains an equivalent of only 1.5 pounds per day of free sulfur. Similar success has been reported by companies who have used water-washing only, but where the water contained small amounts of air.

The water-washing and polysulfide injection did not protect the shell cover of the aftercooler nor the floating head of the tube bundle, since the space between these constitutes a fairly stagnant volume.

Five months after the first hydrogen blister in the shell cover was detected, the number had increased to eight, some of which were as large as two inches by four inches. Further growing and linking up of these blisters was prevented by drilling these blisters from the outside to relieve the high-pressure, entrapped hydrogen.

This could be done safely during operation because audigage measurements showed that the blisters were located outside the minimum vessel-wall thickness required for strength. Of interest was that after drilling these blisters collapsed, as apparently the yield strength of the steel had not been exceeded.

Inspection of this aftercooler revealed severe hydrogen blistering on the inside of the shell cover. Blisters were punctured and the shell cover on the inside metal-sprayed with 0.020 inches of aluminum, covered with a sodium-silicate sealer and normalized in a furnace at a temperature of 850 F. for about one hour. To date, the formerly drilled blisters that were plugged with weld metal, have not started growing again, indicating the effectiveness of the aluminum coating in resisting the wet hydrogen-sulfide attack.

Visual inspection also showed the hydrogen blisters formed during the initial two months when no water-washing and polysulfide protection were provided. They were located in the outlet distributor and in the distributor liner. Figure 5 shows the hundreds of very small blisters that could be seen as shadows when a bright light was placed near the surface of the distributor liner. Also fissuring and cracking can be seen at the welds and in the adjacent stressed area.

For more sensitive control a retractable hydrogen probe was installed in the outlet distributor in addition to the existing fixed probe in the outlet line. Water-washing and polysulfide injection are being applied on a continuous basis.

Since the startup of the unit, no probe activity, nor ferrocyanide findings in the water-draw, have occurred and iron counts have been low. All of these indicate that protection against hydrogen blistering is afforded. The new, separate hydrogen-sulfide absorber for the water-reclaimer overhead gases will do much to alleviate the severity of hydrogen attack at this location.

The primary aim in the design stage of the fluid unit was to protect

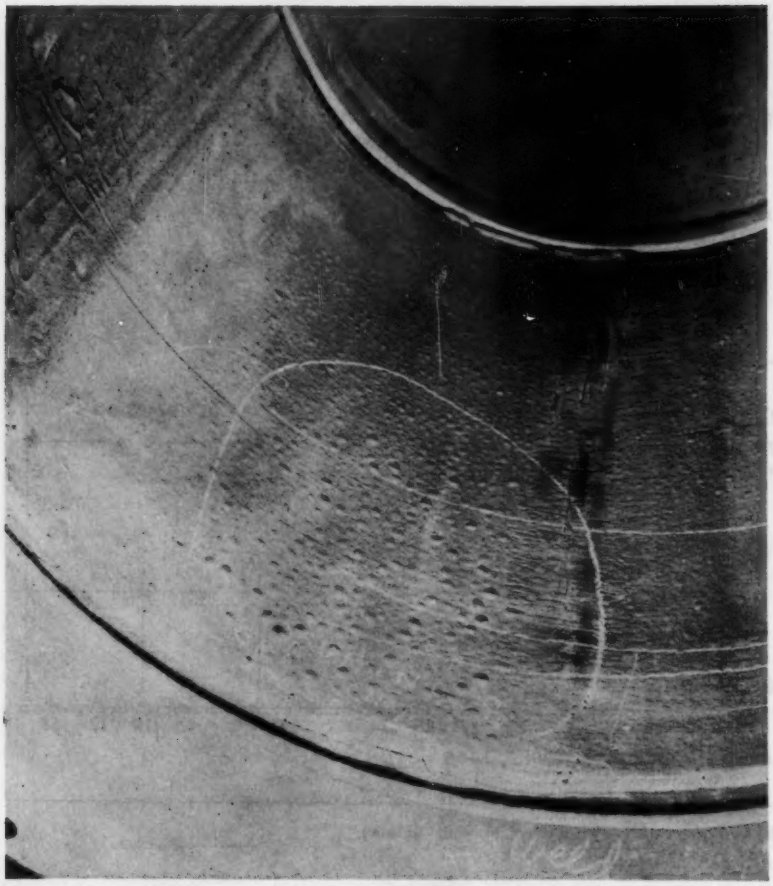

FIGURE 5—Visual inspection reveals many small blisters and cracking at the welds.

the high-pressure stabilization section. This section had been, in other units, the most vulnerable to hydrogen attack. An evaluation by hydrogen probes, painted-can tests and chemical analyses indicate that the method is successful. In addition, a very thorough inspection of the fluid unit after 14 months of operation, showed that the absorber-demethanizer and the towers, overhead condensers and accumulators of the debutanizer, de-ethanizer and depropanizer were in excellent condition. No signs of hydrogen blistering or fissuring could be detected here.

Originally presented at NACE's Twelfth Annual Conference, New York City, March 12, 1956.

ACKNOWLEDGMENT

The authors wish to express their appreciation to Richfield Oil Corporation for permission to publish this paper. Thanks are due to E. C. Herthel for promoting the investigation into the problem of hydrogen blistering, and to our many associates in the refinery who assisted in the various phases of the work.

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B. W. NEUMAIER has been chief process engineer at Richfield Oil Corp. since 1945. Prior to that he was with the Sinclair Research and Development department at East Chicago, Indiana, for 16 years, five of which he spent as assistant director of the cracking division. Neumaier holds a B.S. degree in chemical engineering from Pennsylvania State University and is an active member of the American Institute of Chemical Engineers and the California Natural Gasoline Association.

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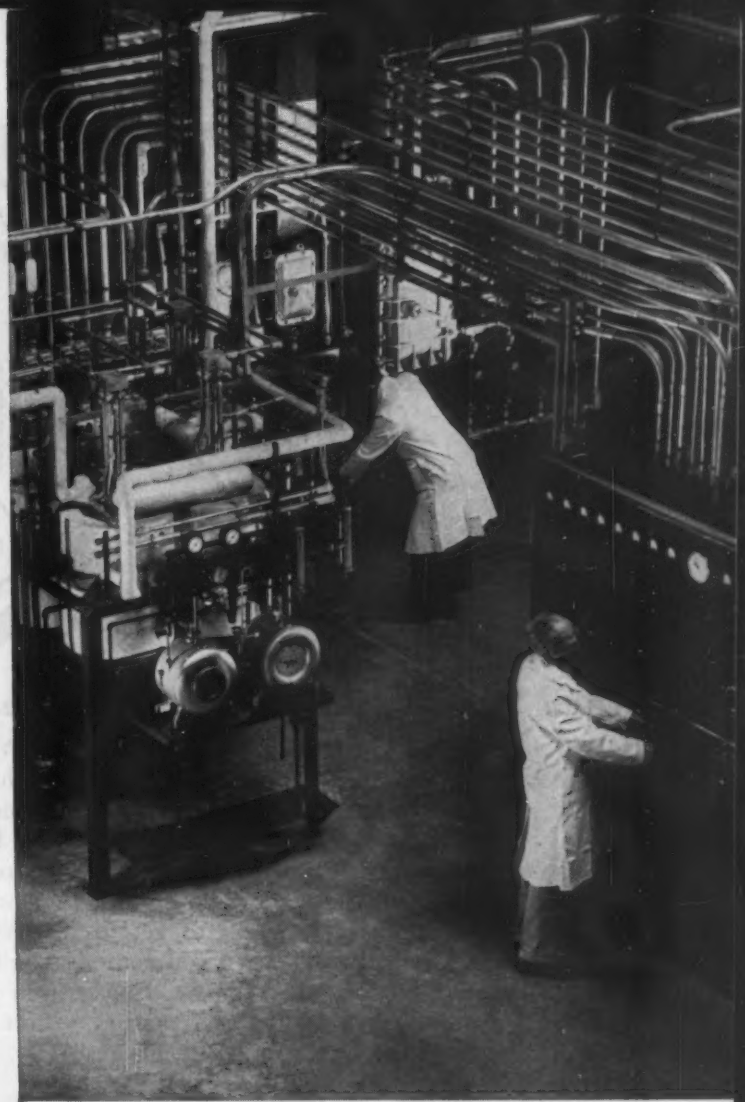
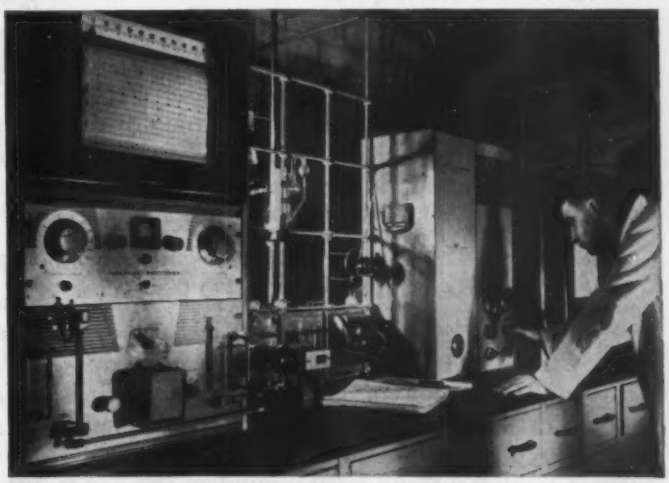
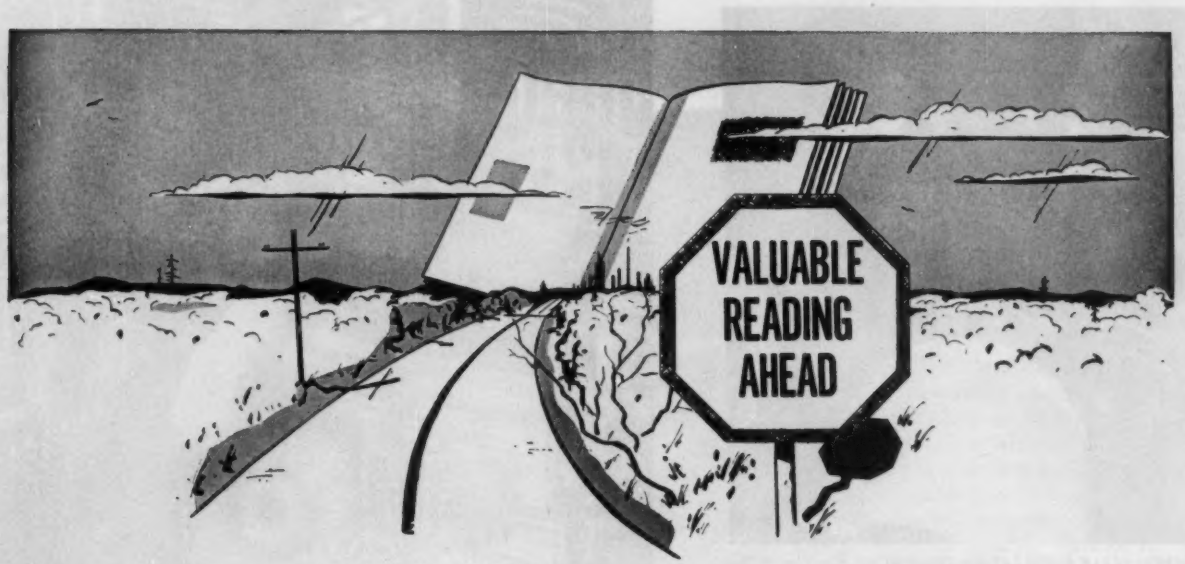


MOST PILOT UNITS at The Center are put together from standard "building blocks." Skid-mounted charging units such as the one at left hold tanks, heaters and pumps for transfer and metering. Process equipment, here shown in background center, can be widely varied. At right is electrical control cabinet. All switches, relays and controls not housed in explosion-proof boxes are enclosed in cabinets like this one, pressurized with outside air to exclude process vapors.



ANALYSIS OF MATERIALS processed and produced in pilot operations at The Center is an important part of the work carried out by Lummus engineers. Here a laboratory technician determines the composition of a multiple-component gas, using a gas chromatography technique.



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PETROLEUM REFINER'S "What's Happening In the Industry" is an accurate presentation of those items that made the news last month. The clear and concise manner in which the events are reported is just what's needed by busy industry men who don't have time to wade through unimportant details to get to the meat of the subject. And when you come to the end of this section, you'll find "Changing Times," a list of rapid-fire news flashes that provide the final touch for keeping you informed. Now is the time to read—"What's Happening In the Industry."

Keep Going to Page 392

Plant Techniques

Heading the list of this month's book reviews is a report on *Techniques of Plant Maintenance and Engineering 1957*. Eight other books are also reviewed for your reading pleasure, so be sure to see "Reviewing New Books."

Keep Going to Page 330

Who's Meeting Where?

You'll find out when you read PETROLEUM REFINER'S "Meeting Calendar"—that easy-to-read tabulation of what's coming up in societies and associations that are of most interest to you. It's the type of thing you'll want to clip out and keep around so you can refer to it at a moment's notice.

Keep Going to Page 408

Dead Stock Won't Do

When sampling a process line, the product in the coil cooler should be completely removed before taking a sample. In this month's "How To Do It" PETROLEUM REFINER presents to its readers, an assured method for completely removing the "dead stock." There's also a tester which you can build which will help you locate weak spots in ropes, and a way that you can reduce foam loss when fighting tank fires. Be sure to read "How To Do It."

Keep Going to Page 333

Are You There?

Is your name in this month's "What's Happening Among Men in the Industry?" If you've been promoted or changed jobs lately, then you're probably listed. But if you're not there this month, go ahead and read it anyway—it's packed with news of the people you went to school with, and those who work around you. Don't miss it.

Keep Going to Page 412

Gasket News!

If you're faced with the problems resulting from excessive leakage across fractionating trays, it may pay you to look into an improvement that a large east coast refinery was able to attain with a new type of gasketing. It's all there for you to learn about in this month's "What's New in Equipment and Manufacturers Literature."

Keep Going to Page 470

MATCHLESS STEAM HOSE

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Scalding steam is a powerful work-saving servant—but let it get out of hand and it can mean sudden death. Yet this valuable, though unruly demon is tamed by a hose that is *absolutely safe*—U. S. Matchless® Steam Hose. This hose cannot burst—even with steam pressures up to 200 pounds. After long, safe service—far longer than ordinary steam hose—the wall structure, instead of bursting, allows a trickle of steam to merely *leak* through—reducing the pressure and giving plenty of notice that a replacement is finally needed. Safety councils give U. S. Matchless their full approval.

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Reviewing New Books . . .

"Techniques of Plant Maintenance and Engineereng 1957"

This is a report of the National Plant Maintenance and Engineering Conference, held in conjunction with the National Plant Maintenance and Engineering Show at Cleveland, January, 1957. The conference is held each year to permit plant engineers and maintenance managers to exchange experience.

This book is a record of those discussions. It includes both the prepared papers and the informal extemporaneous question-and-answer sessions that followed. It is the eighth in the series which began with the first conference in 1950.

(Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y., 273 pages, $10.00.)

"Flammable Liquids Code"

This code just released by the National Fire Protection Association, deals with all phases of flammable liquids, storage and handling. It supplants the former Suggested Ordinance on Flammable Liquids and its new form is intended to be used not only as a basis of municipal ordinances but also as the basis of state or provincial regulations.

Suggested material pertaining to municipal legal regulations in the new edition is now included in an appendix. Other appendices include Protection of Tanks Containing Flammable Liquids in Locations That May Be Flooded, and Abandonment or Removal of Underground Tanks.

Its treatment of tanks, piping, gasoline pumps and many other phases of the subject is drawn with the idea of providing a reasonable regulation in the interest of public safety.

(NFPA No. 30, National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 64 pages, 60 cents.)

"Standard for the Installation of Oil Burning Equipment"

This standard which was just released by the National Fire Protection Association, deals with the installation of all types of oil burning appliances including burners, tanks, automatic controls and other features. As revised, the standard incorporates over 50 changes from the 1956 edition and is suitable for adoption as the basis of a municipal ordinance and covers in one document the regulations of all types of oil burning equipment which formerly were covered in several separate pamphlets.

NFPA No. 31 was prepared by a representative technical committee and is based upon extensive deliberations in the committee over a considerable period of years. It is the latest in a long series of standards dating back to 1902 when the NFPA first inaugurated work.

(NFPA No. 31, National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 64 pages, 60 cents.)

A Recommended Commercial Standard for Asphalt Insulating Siding

The specification represents the composite views of the Insulating Siding Association and representative distributors and users, including the Federal Housing Administration and the National Bureau of Standards.

Requirements and methods of test for various characteristics of the material are covered. Also included are provisisons for labeling and application.

(Write for TS-5341, H. A. Bonnet, Commodity Standards Division, U. S. Department of Commerce, Washington 25, D. C.)

"Standard on Procedures for Cleaning or Safeguarding Small Tanks and Containers"

This standard is new in its field and represents authoritative information as to best methods of avoiding fires and explosions when welding or doing other work on small containers. It is the result of the deliberation of several committees over a period of several years.

Just released by the National Fire Protection Association, this standard was developed jointly by the Sectional Committee on Maintenance and Repair of the Committee on Flammable Liquids with Theron H. Wright of the Ohio Inspection Bureau as chairman and by the NFPA Committee on Gases of which Franklin R. Fetherston of the Compressed Gas Association and the Liquefied Petroleum Gas Association is chairman. It was reviewed by the NFPA Committee on Flammable Liquids.

(NFPA No. 327, National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 12 pages, 40 cents.)

"Standard for the Storage and Handling of Liquefied Petroleum Gases"

This standard just released by the National Fire Protection Association, details provisions for the safe storage and handling of liquefied petroleum gases. It was prepared by a representative NFPA technical committee under the chairmanship of Franklin R. Fetherston of the Compressed Gas Association and the Liquefied Petroleum Gas Association, Inc.

The principal changes in the 1957 edition are the inclusion of a new term "container assembly," LP-Gas refrigerated storage systems are no longer covered, recognition of the 1956 ASME Code, the use of ICC containers permanently mounted on industrial trucks, precautions necessary when parking a loaded trailer or semi-trailer, and revision of several other paragraphs for the sake of clarity.

(NFPA No. 58, National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 80 pages, 50 cents.)

"Standard for the Installation and Operation of Gas Systems for Welding and Cutting"

This standard has just been released by the National Fire Protection Association, and deals with the installation and operation of all gas welding and cutting systems, and covers all gases when used with oxygen for welding, cutting, heating and heat-treating operations. It also provides information on the safe storage of calcium carbide and gases used in these processes. In its revised form, the standard more clearly defines limitations for the storage of calcium carbide.

(NFPA No. 51, National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 28 pages, 50 cents.)

Library of Congress Bibliography on Infrared Volume II

This bibliography includes references to unclassified reports and documents and to formerly restricted reports issued from 1931 to 1952 on the subject. These have been found by a systematic search of the catalog cards, reference lists, and report files of 17 American and British governmental agencies and American universities.

All material concerned with the scientific aspects of infrared radiation and its effects, and all technical applications, with the exception of its use in industrial heating and drying processes, have been included.

(Ask for PB 121998 OTS, U. S. Department of Commerce, Washington 25, D. C., $3.00. Volume I, PB 111643, of the bibliography is also available from OTS, $3.00).

"Materials Handling Equipment"

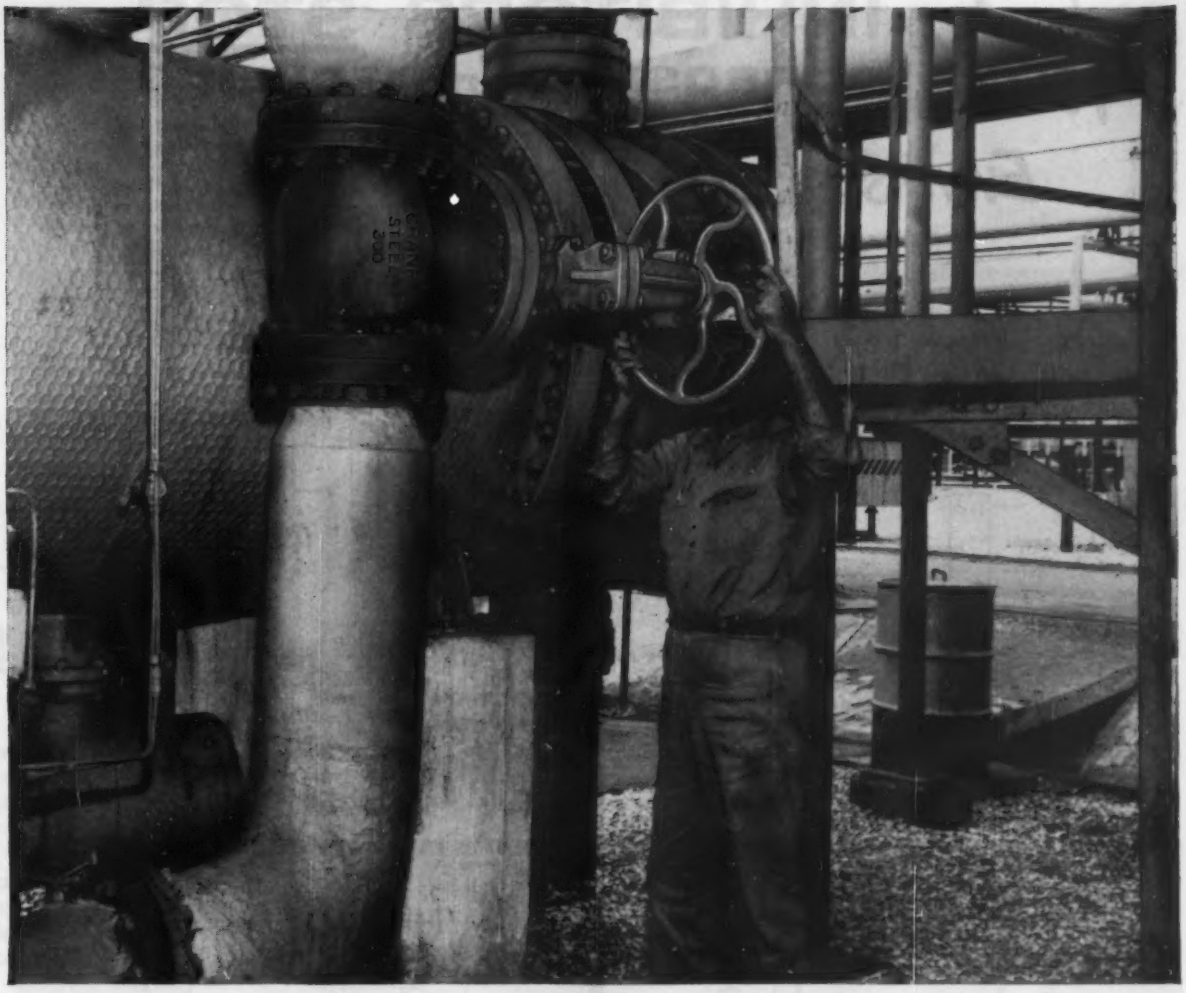
The author, D. Oliphant Haynes, is a world-recognized authority and has served as consultant for such diverse firms as Creole Petroleum Corp. (Standard Oil of New Jersey, Venezuelan affiliate); Grand Union Stores; New Haven & Hartford R. R. Co.; Robert Hall Clothes; Royal Dutch Shell; Merchants Refrigerating Co., and many others. This work is the culmination of a lifetime spent in the search for better, cost-saving, modern materials handling methods.

Industry has long recognized that materials handling is an important factor in manufacturing cost, it being estimated that 25 percent or more of the cost of production is paid out for the handling of material. These costs have been buried in overhead charges and have not been clearly identified to attract their just share of attention by top management. That is why this book is so timely and important and provides a golden opportunity for study, improvement, and cost reduction for every one in business and industry.

Here then will be found the topics considered essential for the basic text: Basic types of equipment and their capabilities, unit-load handling, in-process handling, integration of production machinery with handling equipment, package handling, techniques for analyzing specific problems, analysis and design of handling systems, cost analysis, and organization and control of handling systems. These, and many more, are included in this comprehensive book.

(Chilton Book Division, 56th & Chestnut Sts., Philadelphia 39, Pa., $17.50, 626 pages.)

How Cit-Con stopped valve leakage in lube oil extraction



These Crane valves defy hot oil at 550° F.

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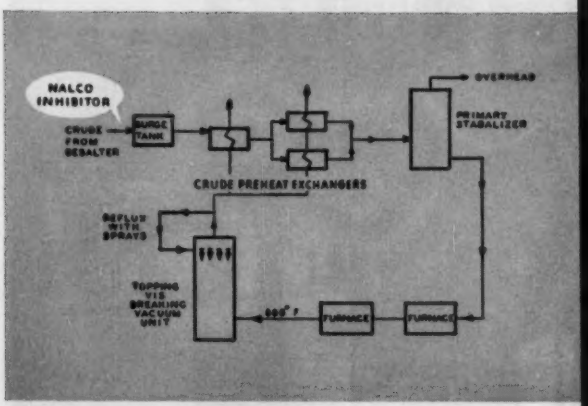
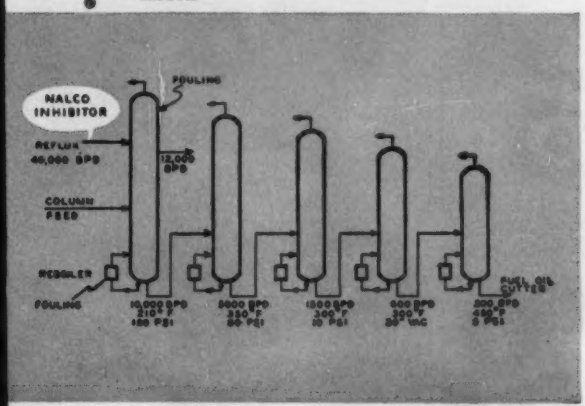


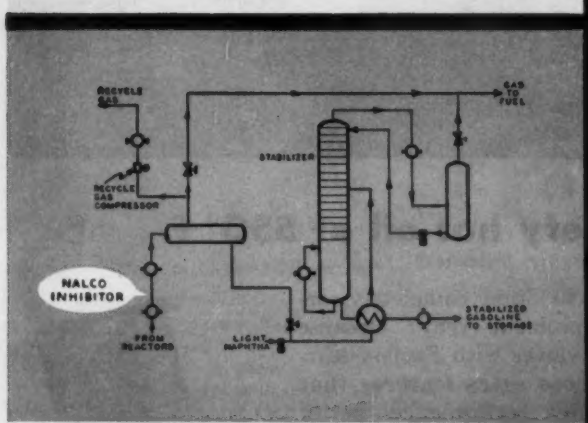
CRUDE PREHEAT EXCHANGERS

The Problem: Fouling. *The Treatment:* 15 ppm of Nalco Inhibitor. *The Results:* Normal temperatures regained in exchangers after five weeks of treatment. Actual reduction of 4 days of downtime due to cleaner condition of treated units.



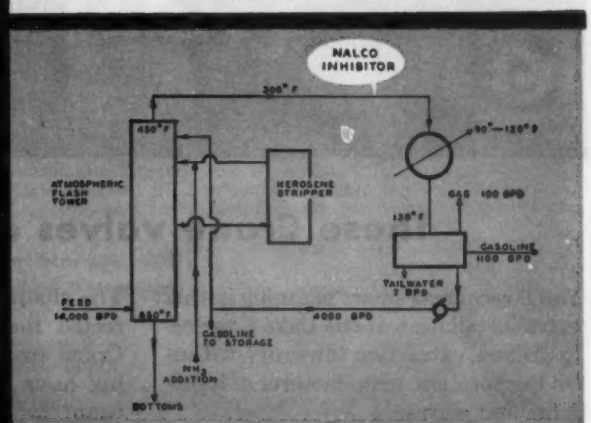
ALKYLATION SYSTEM

The Problem: Reboiler fouling. *The Treatment:* Nalco Inhibitor fed to reflux of left tower. *The Results:* No water washing or mechanical cleaning of system needed after full year of operation. Refinery costs and inconvenience reduced considerably. Greater production realized.



PLATINUM REFORMING UNIT

The Problem: Severe corrosion of exchangers and accumulator after the reactors due to an unusually high halogen acid contamination which held pH about 1.3. *The Treatment:* Nalco Inhibitor into reactor effluent. *The Results:* Iron content reduced from 13.9 to low of 0.73 lbs. per day, far lower than with other inhibitors at greater dosage.



DELAYED COKING UNIT

The Problem: Corrosion of overhead condenser, accumulator and stream pumps. Small amounts of iron sulfide "scaling" in flash tower. *The Treatment:* Nalco Inhibitor added to overhead stream. *The Results:* Iron content of tail water reduced from 300-1000 ppm to approximately 1-20 ppm. Corrosion and scaling stopped.

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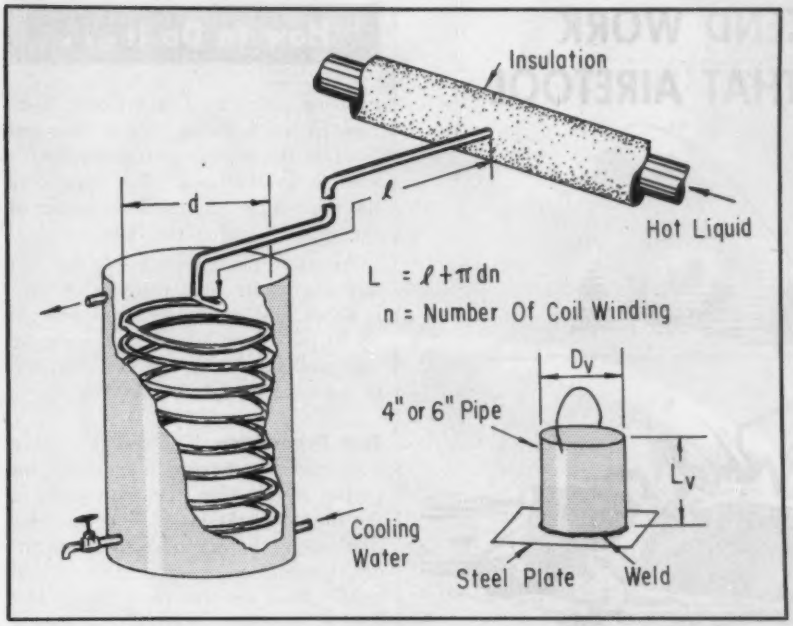


How To Do It . . .

Discard 'Dead Stock' for True Sample

When sampling a process line, the product in the coil cooler should be completely removed before taking a sample. Here's a simple device that assures removal of the "dead stock."

When a stream sample is to be taken from a hot process transfer line, a simple box type coil cooler usually is used to bring down the temperature of the liquid.

In order to obtain a correct sample, operators are instructed to discard a *sufficient* amount of the liquid, which is assumed as the "dead stock" in the coil, before collecting into the sampling bottle. But the word "sufficient" is a vague expression. To make this clear, a small vessel made from an ordinary four or six inch pipe, as shown in the figure, may be used.

The length of the pipe to be used as the vessel is calculated easily as follows:

$$L_v = \frac{(D_s)^2 \times L_s}{(D_v)^2} \times 2$$

where, L_v = Length of the pipe to be used as the vessel.

D_v = Inside diameter of the pipe to be used as the vessel

L_s = Length of the pipe used in the sampling connection.

D_s = Inside diameter of the pipe used in the sampling connection.

The multiplication factor of 2 is for safety. Now, you can instruct your operator to discard a "vesselful" of the liquid instead of "a sufficient amount."

Idea submitted by:

S. C. Ting
Kaohsiung Refinery
Kaohsiung, Taiwan

This Shop-Built Tester Helps Locate Weak Spots in Ropes

To detect and eliminate weakened rope slings before they fail under load, engineers at Calumet & Hecla's Wolverine Tube division in Detroit designed and built a simple, rugged, mobile rope tester out of spare parts.

The framework of the tester consists of an 18-foot-long H-beam supported by four braced angle-iron legs welded to the beam's flanges. Each pair of legs is supported on a caster mounted length of U-channel.

An eight-inch I.D. air hydraulic cylinder with a 15-inch stroke, taken from a scrapped machine, provides the force for testing the slings. The cylinder is bolted to the web of the H-channel, and a hook is mounted on the

NO MORE WEEKEND WORK FOR ME, NOW THAT AIRETOOL IS ON THE JOB

"I'm a refinery Maintenance Supervisor, and believe me when I say that buying AIRETOOL EQUIPMENT for our maintenance program was the smartest move we've made in a long time.

"We pull maintenance on heat exchangers and condensers quicker now than we ever did. With our new AIRETOOL EQUIPMENT my crew can clean those tubes, cut 'em out if they're bad, and roll in new ones in hours instead of days. No more struggling through Saturdays and Sundays to get the job done.

"And listen . . . with that new AIRETOOL Automatic Expansion Control System, my gang rolls such perfect, tight tube joints that I can forget about leaky tube joints.

"So brother, if *you're* a tube maintenance man, take my advice . . . let AIRETOOL MAINTENANCE EQUIPMENT help you. You'll lower your maintenance and repair cost sheet so far you'll be able to hear the front office boys clickin' their heels clean across the plant. You might even be able to join me for a little fishin' trip some weekend. But now's the time to act, mister . . . those big ones are hittin' and you can't catch 'em workin' overtime."

AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

Send for AIRETOOL BULLETIN NO. 60. Illustrated, detailed information on all AIRETOOL Tube Maintenance equipment, plus Airetool's specialty tools . . . AIRETOOL'S new, light-weight, air-motor grinders . . . and AIRETOOL'S Automatic Tube Expansion Control System.

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge

REPRESENTATIVES: in principal cities of U. S., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii

EUROPEAN PLANT: Vlaardingen, The Netherlands

CANADIAN PLANT: Brantford, Ontario

How to Do It . . .

cylinder plunger. The cylinder hook runs in a groove so that it does not twist as the rope is put under tensile load. A double hook, which can serve for both rope lengths, is mounted at the opposite end of the H-beam.

Air at 80 psi is supplied to the unit and a pressure regulating valve steps it down and maintains a pressure of 38-40 psi to the cylinder. A moisture trap and lubricator are also installed in the compressed air line.

Test Procedure. The test procedure is simple. A rope sling is mounted for testing by slipping the loop ends of the sling over the hooks. The operator then opens the air valve to the cylinder, thereby applying a 2000 pound tensile load on the rope sling. The load is maintained until rope creepage stops. A sling in satisfactory condition will "give" a certain degree and then hold steady. A faulty sling will continue to creep until breakage occurs.

Electric Motor Troubles? Then Use This Checklist

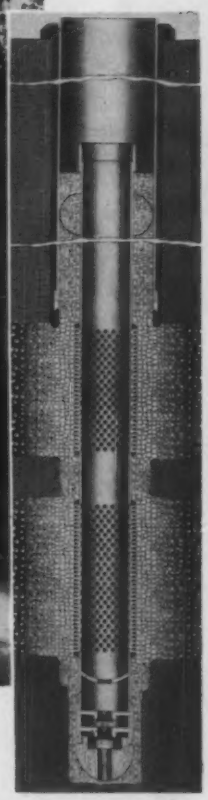
When bearings are too hot to touch or, are smoking, the cause may be a dry bearing insufficient oil, oil rings not working, a dirty bearing, or a tight bearing which calls for scraping both bearing and shaft or replacing the bearing. In the case of malfunctioning oil rings, they have probably worked out of their slots and should be replaced.

A bearing may also be binding if the shaft is not running true, or if the bearing itself is out-of-round because of excessive strain on the pulley, or if it has been loosened by vibration. In the case of bearing vibration, the trouble can generally be corrected by tightening the set screws holding the bearing in its journal housing.

Warm bearings are generally caused by an overload on the motor through heat being transferred from the rotor or the stator of the motor. And, in such a case, the load should be decreased or a larger motor used.

Smoking windings or charred wedges over the coils indicate that the bearing is worn on one side. If this is

Testing 1 of 3 wells producing 6,000,000 gallons daily for Texas Butadiene.



Cross Section showing construction of Tru-Gravel-Wall Well

Ample Underground Water for Industry from "Tru-Gravel-Wall" Wells

Water for rapidly growing industry is scarce today in some areas. But where underground water is available it can be produced with a new measure of efficiency . . . if our "Tru-Gravel-Wall" type of well . . . the truly scientific method of producing water . . . is constructed.

Gravel-wall-well construction dates back almost 60 years, yet only recently has this process been perfected. About ten years ago our company determined to perfect gravel-wall techniques. Here at Houston we had a made-to-order laboratory, as the City of Houston is the world's largest user of underground water.

Since that time we have constructed 20 gravel-wall wells for Houston. The City requires that each well shall have a specific capacity of 25 gpf, shall produce 3,240,000 gallons per day, and shall have a sand content not exceeding 1 ounce per 200 gallons.

Our first well showed a specific capacity of 35 gpf, 40% above guarantee. We steadily improved our techniques, and specific capacities on subsequent wells increased rapidly. Our most recent wells for the City have tested approximately 60 gpf, or *140% above guarantee!* This figure constitutes a standing record for this area.

The Tru-Gravel-Wall Well pictured above is one of three drilled for the Texas Butadiene & Chemical Corporation for their new Lyondell plant, which has the distinction of being the first privately financed synthetic rubber plant built. This plant circulates 150,000,000 gallons of water daily through one of the largest cooling towers ever built. A fresh water supply of 6,000,000 gallons was needed daily.

The 3 wells, drilled to depths of slightly over 1600 feet, each penetrated 9 water sands and required 250 feet of screen. Constructed to provide 6,000,000 gallons daily, the wells were successfully tested for a total of 10,000,000 gallons daily. Our contract covered a complete turnkey job. We drilled the test holes, drilled, developed and equipped the wells complete.

Our new 40-page booklet shown at right tells the story of Tru-Gravel-Wall Wells in full detail. We believe you would find this booklet of basic value and interest. The coupon at right will bring you a copy with our compliments.

TEXAS WATER WELLS, INC.
951 McCarty Drive, Houston 29, Texas.

Gentlemen: Without obligation, please mail me your new booklet, "Gravel-Wall Technique . . . Perfected!"

NAME_____

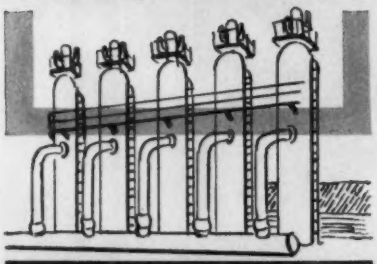
COMPANY_____

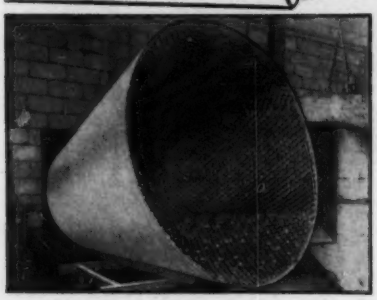
STREET_____

CITY_____ STATE_____

TRU-GRAVEL-WALL WELLS

FEWER "TURN-AROUNDS"





Shutdowns for repairs of fire clay linings in refractory units are expensive. The frequency and duration of these shutdowns can be greatly reduced by the use of a steel grating armor known as "Gridsteel", which holds the castable refractory linings in place longer and armors them against the bombardment of catalytic elements.

"Gridsteel" is available in a special loose clinch to conform easily to curved surfaces.

For complete information, write for brochure on Irving "Gridsteel" Contour Retainer Mesh

★

"A Fitting Grating for Every Purpose"

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IRVING SUBWAY GRATING CO., Inc.
Originators of the Grating Industry

Offices and Plants at
5090 27th St., LONG ISLAND CITY 1, N. Y.
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How to Do It . . .

discovered soon enough, the bearings may be realigned or new wedges inserted to correct the trouble. If the condition is permitted to remain for an extended period, the coils will require replacement.

Starting Failure. Failure of a motor to start can be often caused by the following defects:

- Low voltage which produces insufficient torque. The obvious solution is to increase the voltage.
- A short circuit, caused by rough handling. This will generally occur in the stator windings. The damaged coils may be replaced or the break repaired by jumping the damaged coil or coils.
- Excessive load which will often be the cause of a motor failing to start. This calls for load reduction or the installation of a clutch between the load and the motor.
- Tight bearings which cause friction. Bearing caps can be easily loosened, but if the condition continues, the bearings should be replaced.

A failure to start, where automatic controls are used, is generally caused by the controls themselves. Sometimes the solenoid circuit is not functioning because of an open battery circuit, the arms holding the circuit breaking contacts are not working properly, or because the contacts are dirty or burned.

Symptoms and Remedies. Lagging motor speed is the result of insufficient torque. This is caused by the rotor field discharge switch being in the wrong position whereupon the circuit between the exiter and the motor field windings should be opened. It may also be caused by the motor load being too great.

- Buzzing sounds in the motor are generally caused by a short circuited coil or group, an open circuit, or a ground. A short circuited coil is generally due to mechanical injury or to broken insulation resulting from overheating. Here we need to install a new coil or jump the injured coil as a temporary expedient.
- Low growling sounds are caused by the rotor being out of the stator magnetic center which in turn means that either the motor is not level or the shaft collars have shifted and there is too great an end play on the shaft.
- When the motor starts and runs but heats up while the stator is cool, the rotor bars are loose or grounded because of abnormal currents in the rotor. The set screws holding the rotor bars to the short circuiting rings should be tightened and soldered or welded and then the grounds removed.
- Half speed running, on a wound rotor motor, is caused by broken connections between the winding and the collector ring or one brush failing to make contact; and, an open circuit in the rotor connections results. The break can be repaired or the worn brush spring replaced easily.
- Failure to start, in addition to the causes mentioned above, can be easily detected by first examining the fuses, then the relays, checking the starter carefully, inspecting the air gap and removing the belt or pulley to find out if there is an overload.
- Explosions sometimes occur in windings while a motor is running hot. Dampness causes circulating currents between the coils, and between any coil and the ground, thus creating a temporary ground or short circuit. Procedure here calls for baking the motor until all dampness is gone, then brushing it with a good insulating varnish. Sometimes it will be found that the coils have been punctured and need replacement.
- Failure to start with the stator handle in the starting position, and accompanied by a humming sound. This is a frequent trouble because the motor is trying to run single phase, an air gap is displaced, or there is an open circuit in the stator windings.
- When the motor is trying to run single phase, it is generally because one fuse is blown or one overload relay is out of order. This can be easily handled by adjustment of the relay or replacement of the fuse.

In the second named trouble, the bearing is "out of true" and should be shimmed or replaced with a new bearing if possible to do so.

- Where an open circuit develops in the stator windings, the cause is either a short circuit, which has punctured a coil, or the result of rough handling.
- Sometimes when a motor has been repaired and replaced, it will seem to run "light" with an unusual sound and intervals of speed changes. Gen-

For more data on advertised products, use Readers' Service Cards, last page.

DU PONT *Petroleum Chemicals* NEWS

Number 79 in a Series of Bulletins for the Petroleum Industry

SEPTEMBER 1957

New survey reveals hidden buying motivations of service station customers

Refiners realize substantial savings by purchasing additives in quantity

If you are now buying your additives in drums, you can *save well over a thousand dollars each time you order* a Du Pont additive by the tank car.

With Du Pont Fuel Oil Additive No. 2, for example, a Mid-Continent refiner can save 8.4% on a carload by simply taking delivery in a 4000-gallon tank car instead of an equal quantity in partial car drum shipments. With Du Pont Antioxidant No. 22, the savings range as high as 8.9%.

These figures are, of course, based on freight rates between specific points, and the savings vary according to the shipping distances.

How much can YOU save?

To answer that question for you, one of our representatives will be glad to call at your refinery and study applicable freight rates and inventory patterns. He will then determine the most convenient handling method for you, and figure the exact saving you can make.

Still another in a series of Du Pont-sponsored surveys has recently been completed by National Analysts, Inc. The findings will soon be available in booklet form.

The objective of the survey was to determine what emotional reactions influence motorists to choose a service station, a brand of gasoline, or a TBA product.

THE NEW DU PONT MOTIVATION SURVEY REPORT has been packaged as a convenient flannelboard presentation. Roberts W. Brokaw, of Petroleum Chemicals Sales Promotion, demonstrates here how the results can be presented at meetings in easy-to-understand form.

Psychological needs

The psychologists in conducting the study determined that there are four basic needs which can be fulfilled through purchase of service station products and services:

1. **Play**—use of car for recreation

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DUPONT *Petroleum Chemicals* NEWS

CONTINUED

New Survey

2. **Aggression**—desire for speed and fast acceleration
3. **Conservance**—need to preserve car as an investment
4. **Infavoidance**—the desire to avoid the *appearance* of inferiority

Specific products

Gasoline sales, as you might suspect, are most influenced by the play and aggression needs. This finding indicates that gasoline advertising should appeal to motorists' desire for recreation and powerful car performance.

It was found that motor oil and grease satisfy the conservance need. The promotion of these products should be directed accordingly. Body polish, which might be thought to satisfy the conservance need, actually gratifies more often the need for infavoidance. So do white sidewall tires.

Anxiety influences

Two of the areas explored were anxieties about product quality and service.

Apparently women drivers are more concerned than men about tire quality and repair. This may be because a flat tire is a greater inconvenience to women.

Women appear to have also a more generalized anxiety over automotive products they buy. This is possibly due to their having, in general, less mechanical knowledge than men.

Perceptions of service stations

Motivational needs lead to motorists' perception of different service stations as places to do business. Perception is influenced also by the opinions of others, including families, and by advertising and promotion of the dealer or the company he represents.

A summary of the findings of the survey are being published in book form for easy reference.

AUTOMOTIVE SERVICE OFFERED

I. T. (TED) ROSENLUND (right) says that actual under-the-hood technical service work on refiners' automotive problems is his greatest source of new ideas. And many of his ideas have resulted in unique demonstration equipment which enables refiners and marketers to prove their product quality to dealers and customers.

He is responsible for the design and construction of practical demonstration equipment for the Petroleum Chemicals Division. This equipment must make somewhat intangible fuel and lubricant properties come to life in the form of noise or motion. With it petroleum refiners and marketers can show their dealers and customers the quality built into their products.

Wide experience

Ted's long experience in automotive service work also enables him to assist in resolving particularly difficult problems as they arise.

Ted joined the DuPont Company in 1947 as manager of the Petroleum Chemicals Division's road test laboratory. Between 1942 and 1947, he had been fuel and lubrication engineer for the Allison Division of General Motors and a project engineer on combustion chamber design and development at the Packard Motor Car Company's jet engine division. Prior to 1942, he spent several years with a major oil company as research engineer on aircraft engine oil development.

Ted graduated from the University of Michigan with a BS degree in aeronautical engineering, majoring in engine design. He is a member of the Society of Automotive Engineers.

Expanded additives warehouse to serve Pacific Northwest area

The DuPont Petroleum Chemicals Division recently expanded its additives warehouse near Seattle.

Ideally located to serve the fast-growing refinery industry in the Pacific Northwest, it will continuously house an ample supply of all DuPont petroleum additives (except tetraethyl lead). The complete DuPont line includes Fuel Oil Additive No. 2, DuPont Metal Deactivator, dyes, antioxidants, and grease additives.

For fast deliveries

Arrangements with a local truck line plus the permanent warehouse staff will help considerably to expedite deliveries of DuPont additives to refiners.

DuPont TEL is supplied to refiners in this area from a DuPont "warehouse on wheels" at Ferndale, Washington.

SALES OFFICES

Chicago 3—8 So. Michigan Ave. . . . RAndolph 6-8630
Cleveland 15—25 Prospect Ave. . . . SUperior 1-1363
Denver 2—Petroleum Club Building, 16th & Broadway . . . . . AComa 2-2347
Houston 2—705 Bank of Commerce Bldg. . . . . CApitol 5-1151
Los Angeles 17—612 So. Flower St. . MAdison 5-1691
New York 20—1270 Ave. of the Americas . . . . . COlumbus 5-2342
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Tulsa 1—1811 So. Baltimore Ave. . . . . LUther 5-5578
In Canada—DuPont Company of Canada (1956) Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12**—Ontario . . . . . HUdson 1-6461
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Better Things for Better Living
. . . through Chemistry

E. I. DU PONT DE NEMOURS & CO. (INC.) • Petroleum Chemicals Division • Wilmington 98, Delaware

OVER

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-5066

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erally this results from the reversing of the coil connections in one phase.

• Burned insulation, brought about by one or more coils in the stator being short circuited, is due to mechanical injury or to broken insulation. Replacement of the coil is the remedy, although the motor may be put into temporary service, if a new coil is unavailable, by jumping the injured coil.

• Variable humming sounds in electric motors are usually caused by a high resistance in the line (generally on long transmissions) or an unstable

How to Do It . . .

speed of the prime mover, on the alternator, supplying the motor.

• Many electric motor troubles can be eliminated by being certain that the highest grade of oil is used in sleeve bearings and the best grade of grease on roller and ball bearings. It has been found that the average electric motor troubles result from either improper oiling or complete lack of maintenance attention.

Reduce Foam Loss in Fighting Tank Fires

A fixed foam delivery system consists of the conventional permanent type installation of one or more foam mixing chambers atop the tank, plus the usual foam feeding manifold and piping. It has long been recognized as the best primary fire-fighting device for fixed-roof tanks. The advantages of this method are:

• Operation is easier and faster in action. It will throw a foam blanket over the entire tank in minutes.

• The equipment is in a fixed position and always ready to deliver foam swiftly, smoothly and efficiently to the burning tank.

There is one difficulty. Foam bubbles are fragile and they are often lost due to submergence in the liquid and the updraft of the fire. Or, they are broken up by impact when they drop from the top entrance to the liquid surface. Several methods have been designed to protect the foam bubbles from being broken. Some of them are as follows:

Moeller Tube Method. This method is limited to the application of a portable foamite applicator or hook-shaped foam tower in cases where a fixed foam delivery system is not installed or where it has been destroyed by an explosion.

The equipment consists of a porous asbestos tube with one end permanently fastened to a gooseneck applicator and the other end fastened to a float, buoyed on the oil surface. Foam is admitted through the open mesh, thereby applying it to the oil surface, gently.

Slide-Channel Method. Beneath the foam delivery nozzle, inside the tank, an inclined open-channel is welded to the tank wall by means of brackets, Figure 1. Foam from the nozzle slides down the channel to the burning oil surface. The sliding action gives a slight push to the foam which disperses it and gives better coverage in the tank.

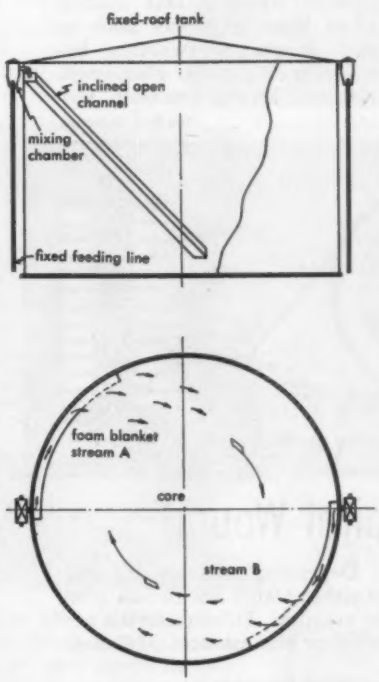


FIGURE 1—Inclined-column method.

Slot-Column Method. A vertical, semicircular slot-column is welded to the inside tank wall by Nelson studs or other means as shown in Figure 2. The column is about 2 feet in radius and extends from the foam delivery nozzle to the tank bottom. The

SPECIALISTS in Tower Packings

Here are several types of tower packing made in one of the Knight plants, the largest in the country specializing in tower packing production.

Knight packing includes the popular and efficient Berl Saddles made of unglazed porcelain and chemical stoneware. Both are sturdy, non-spalling and entirely acid proof. Berl Saddles, made of Permanite or steel, are available for use with strong caustic solutions or HF.

Knight makes other tower packings — including Raschig, Lessing, spiral, and partition rings. We also furnish the new polyethylene Tellerette packing shown.

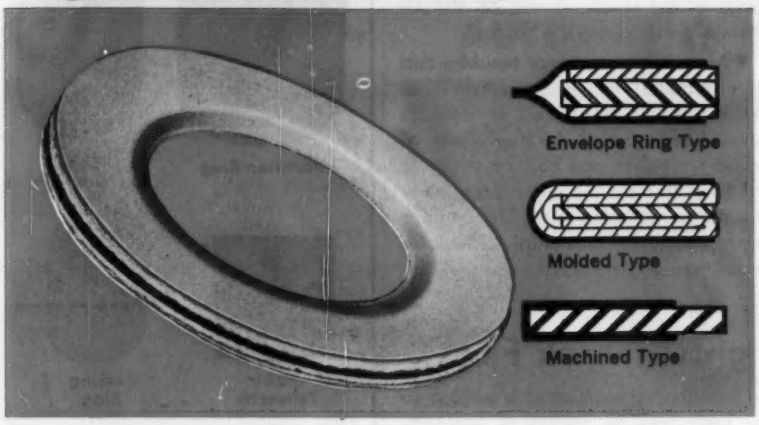
Data concerning sizes, weights, surface area, etc., on our various types of tower packings is given in Knightware Chemical Equipment Bulletin No. 11 — Write for your copy.

Maurice A. Knight
956 Kelly Ave., Akron 9, Ohio

KNIGHT-WARE CHEMICAL EQUIPMENT

For more data on advertised products, use Readers' Service Cards, last page.

GASKETS for every service

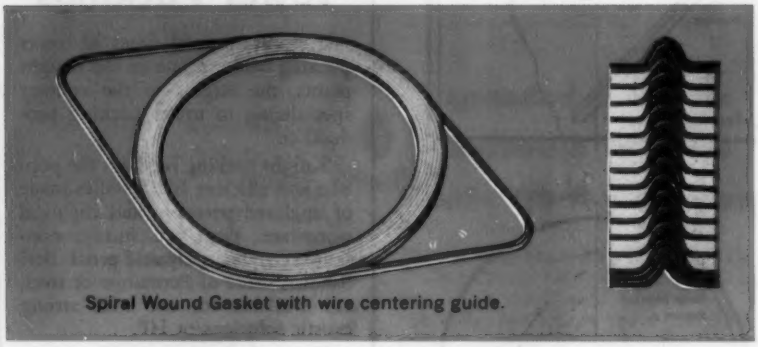


Chemically Impervious TEFLON*

Teflon gaskets in corrosion service provide months of efficient sealing where other materials have failed in hours.

Belmont Teflon Jacketed Gaskets offer special filler materials and inserts which meet specific installation and operating needs with respect to compressibility, resilience and rigidity. Hence, they protect special chemical piping and equipment against excessive bolt loading while insuring perfect seals at each connection—whether between metal, glass, glass-lined, Karbate, Haveg, porcelain, etc.

*du Pont trademark



Spiral Wound Gasket with wire centering guide.

BELMONT Spiral Wound

Belmont Spiral Wound are gaskets with resilience "built in" for positive sealing action under the toughest service conditions.

Depending upon service, metal is either plated low-carbon steel or stainless. Filler materials are white or blue asbestos, or Teflon.

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Such leading Packing Distributors as **Tennessee Mill & Mine Supply Co. in Knoxville** and **J. G. Christopher Co. in Jacksonville** are ready to serve you promptly and helpfully, wherever you are.

The Belmont Packing & Rubber Co. • Butler & Sepviva Sts., Phila. 37, Pa.

BELMONT

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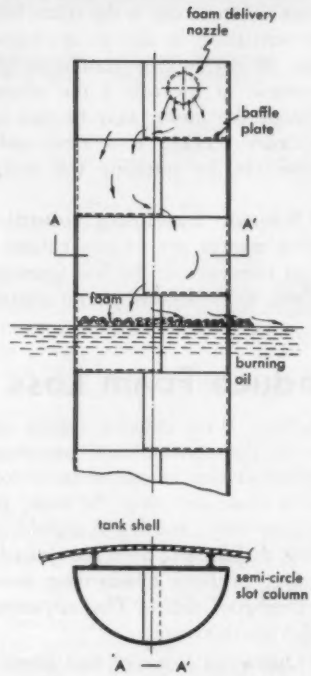


FIGURE 2—Slot-column method.

column is baffled with shaped plates spaced at 3 foot intervals. The slots are placed in alternate positions, down the column, between the baffle plates. If two or more columns are installed in one tank, slots at same tank level are made in the same side of both columns. This valve of such an arrangement is to fully utilize the distributing forces of the different foam streams delivered from the separate columns. It produces a torque which speeds the dispersion of the foam blanket in the tank.

The foam flows down the column gently from plate to plate. It is then delivered to the burning oil surface as a perfect foam blanket. The Chinese Petroleum Corp. decided to adopt the slot-column method. They reasoned that foam bubbles are viscous balloons which have poor slide characteristics. Therefore, the inclined channel may be not completely satisfied for this purpose. However, the Slot-Column is an ideal method for the protection of foam bubbles on their passage to the burning oil surface.

Idea submitted by: Tzen-Yung Yang, Maintenance Engineer, Kaohsiung refinery, Chinese Petroleum Corp., Kaohsiung, Taiwan (Formosa).

PROTECT THOSE THREADS

with MOLYKOTE® LUBRICANTS!

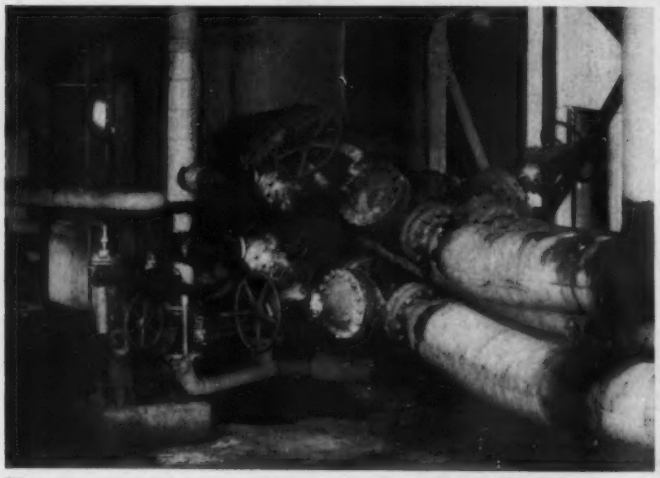
CUT MAKE-UP AND BREAK-OUT TIME BY 40% WITH THIS IDEAL HOT SERVICE THREAD AND JOINT LUBRICANT

Here's hot flange bolting treated with MOLYKOTE Lubricant to prevent galling. Studs can be made up or broken with a fraction of the force needed with bare threads.

MOLYKOTE Lubricants are stable in air to 750° F. and to 1500° F. in H_2 and hydrocarbon vapors . . . well above the point at which most lubricants break down or coke. MOLYKOTE Lubricants are not dissolved by any fluids except strong acids.

Use MOLYKOTE Type G to be sure you won't have to cut out seized studs.

You can protect your ring gaskets, studs and flange grooves on vessels and in piping, and do the job easier with MOLYKOTE Type G.



Here is the kind of hot service where MOLYKOTE Lubricants really pay off! Use it on flange studs, bonnet studs, valve stem and threads, gaskets, valve seat insert threads and sliding or press fits. MOLYKOTE works where nothing else will!

CHECK THESE POINTS ON MOLYKOTE

- **99% Safety Factor Against Galling and Seizing on threads up to 1500° F.**
- **Bonds to Metal. Can't be squeezed out under any pressure.**
- **Will not wash off.**
- **Is not attacked by any but a few strong acids.**

"BREAKING LUBRICATION BARRIERS"

If you haven't yet received your copy of this new brochure, be sure to send for it today. We'll send it without obligation.

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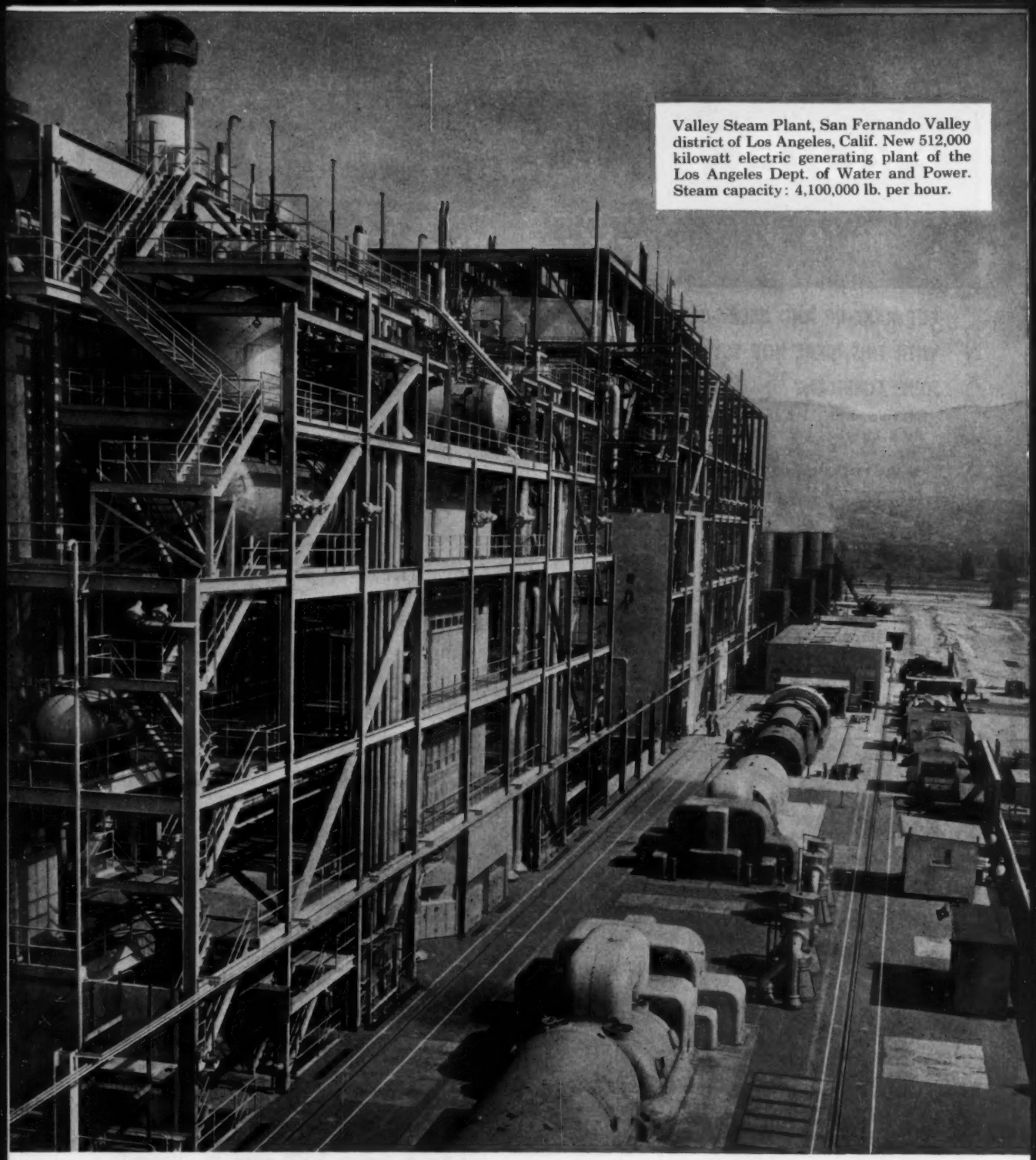
Main Factories: 65 Harvard Ave., Stamford, Conn.
71 Arnulfstrasse, Munich 19, Germany

For more data on advertised products, use Readers' Service Cards, last page.



Valley Steam Plant, San Fernando Valley district of Los Angeles, Calif. New 512,000 kilowatt electric generating plant of the Los Angeles Dept. of Water and Power. Steam capacity: 4,100,000 lb. per hour.

How big Valley Steam Plant demineralizes

• Valley Steam's feedwater requirements are typical for today's modern, high-capacity stations. Its raw water supply, delivered from the Los Angeles Owens River Aqueduct, contains 132 ppm total solids but is high in dissolved silica (18 ppm). The 1500 psig and 1850 psig boilers require a large amount of high quality feedwater.

The 4-step PERMUTIT Demineralizer was custom-designed for this problem . . . not only in size, arrangement and number of ion exchange units, but also in the selection of the ion exchange resins.

That's why Permutit's broad experience with many different demineralizing systems and its manufacture of ion exchange resins as well as equipment are of particular value in solving large-plant water problems.

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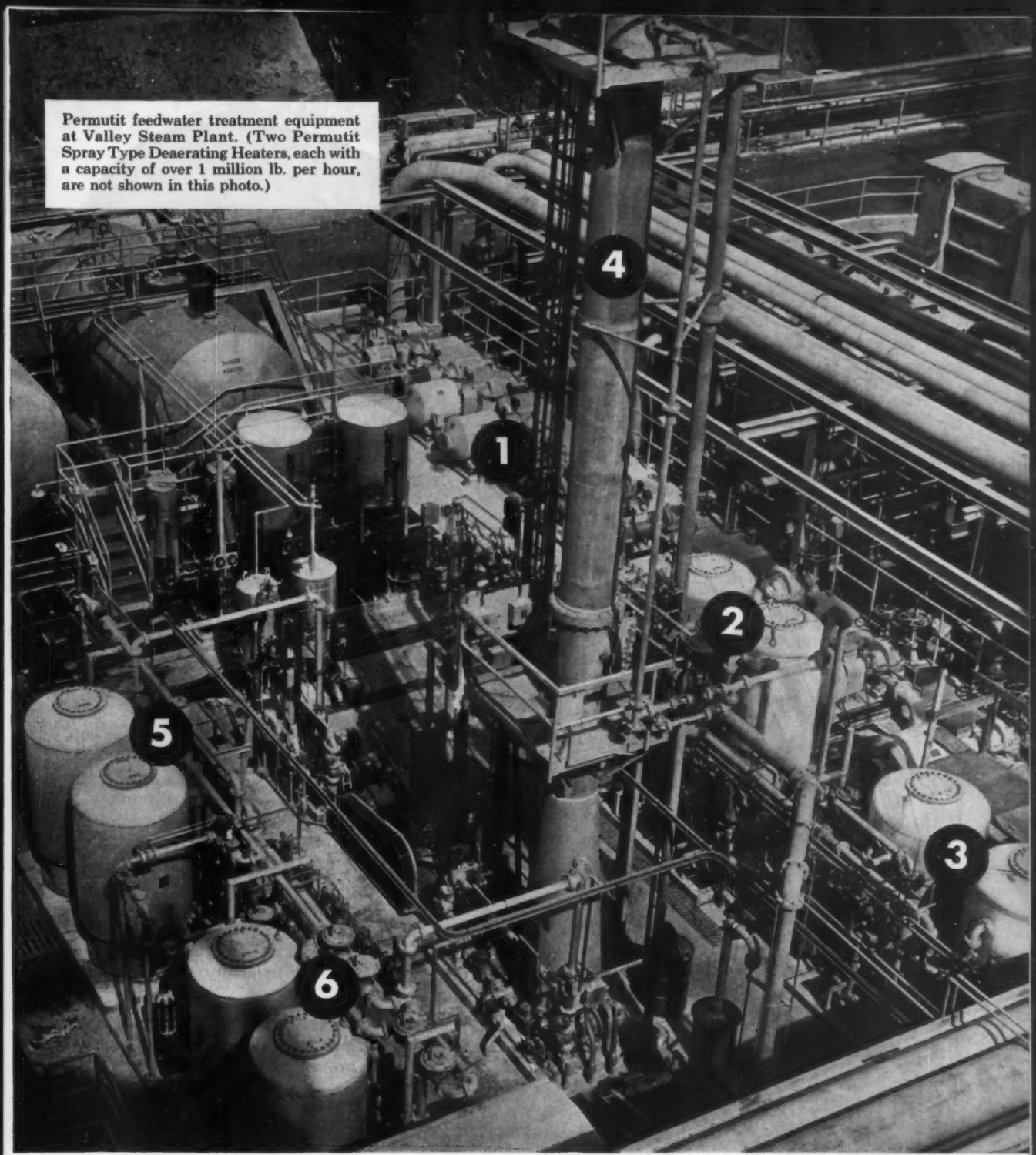

Permutit feedwater treatment equipment at Valley Steam Plant. (Two Permutit Spray Type Deaerating Heaters, each with a capacity of over 1 million lb. per hour, are not shown in this photo.)

its feedwater with PERMUTIT® equipment

1 Diatomite filters (behind column) remove dirt and other suspended matter . . . keep ion-exchanger beds clean for top efficiency.

2 Primary hydrogen cation units contain Permutit Zeo-Karb® . . . remove metallic cations such as calcium, magnesium, sodium.

3 Weakly basic anion units contain Permutit A exchange resin ... remove chlorides, sulfates, nitrates.

4 Vacuum deaerator removes CO_2 at low cost. Reduces the load on the second stage anion exchangers.

5 Secondary hydrogen cation units (Zeo-Karb) "polish" water by removing "slippage" from first cation units.

6 Strongly basic anion units contain Permutit S-2 resin . . . remove dissolved silica . . . also catch "slippage" from first anion units.

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For more data on advertised products, use Readers' Service Cards, last page.

Who's Building . . .

Construction BOXSCORE appears next in October

U.S.I.C. Eyes Gulf Coast For Petrochemical Plant Site

U. S. Industrial Chemicals Co., will build a second plant to produce polyethylene at a new location by National Petro-Chemicals Corp. National Petro-Chemicals is majority owned and managed by U. S. Industrial Chemicals Co., division of National Distillers and Chemical Corp., and minority owned by Panhandle Eastern Pipeline Co.

The new plant, which is scheduled for operation by late 1958, will produce 75 million pounds per year of intermediate density polyethylene resins. Capacity of the present Tuscola, Illinois plant is 100 million pounds per year, making the company's total projected capacity 175 million pounds per year.

A modification of the conventional high-pressure process will be used in the new installation. Resins produced there will be of an intermediate density type, with properties somewhere between those of the original polyethylenes, and the new high-density resins.

Site for the new plant has not been chosen, however, several Gulf Coast sites are under consideration and the company has already optioned land at more than one location.

Engineering of the new plant has not waited for a final decision on location, however, and this phase of the project is already well underway. M. W. Kellogg Co. is handling design and construction.

Also announced was that a new plastics compounding plant would be built near the Tuscola, Ill. polyethylene plant. At this new plant polyethylene will be compounded with colors, carbon black, or other additives. Capacity of the new plant will be 25 million pounds per year. It is scheduled for completion by mid-1958.

Columbia Gas to Recover Appalachian Petrochemicals

Columbia Gas System, Inc., has announced plans for the recovery of petrochemical raw materials from rich Appalachian natural gas streams produced and purchased in Kentucky and West Virginia.

George S. Young, president, said the System will spend about $13 million for the construction of an extraction plant, a fractionation plant and a pipeline to transport a mixed stream of liquid hydrocarbons bewteen the two.

Mr. Young said contracts have been executed between Columbia and J. F. Pritchard & Co., Kansas City, Mo. for the construction of the hydrocarbon extraction plant at Kenova, W. Va. and the hydrocarbon fractionation plant on a 160-acre site at Siloam, Ky. Both plants are scheduled to be in operation about December 1, 1958.

The hydrocarbon extraction plant, which will cost about $8 million will be owned and operated by United Fuel Gas Co., a Columbia subsidiary with headquarters in Charleston, W. Va. It will be built on a site just north of United Fuel's Kenova compressor station, about 12 miles from Huntington, W. Va. and is designed to recover heavier hydrocarbons from 170 million cubic feet of natural gas per day.

Columbia will also build a hydro-

Gilsonite Plant on Stream

American Gilsonite Co.'s new plant near Grand Junction, Colo., was formally opened last month. Charge to the plant, a gilsonite ore, is delivered as a water slurry from the mines about 80 miles away. The ore is processed through a delayed coker (shown above) to produce coke and gasoline for further processing. All intermediate fractions are recycled to extension.

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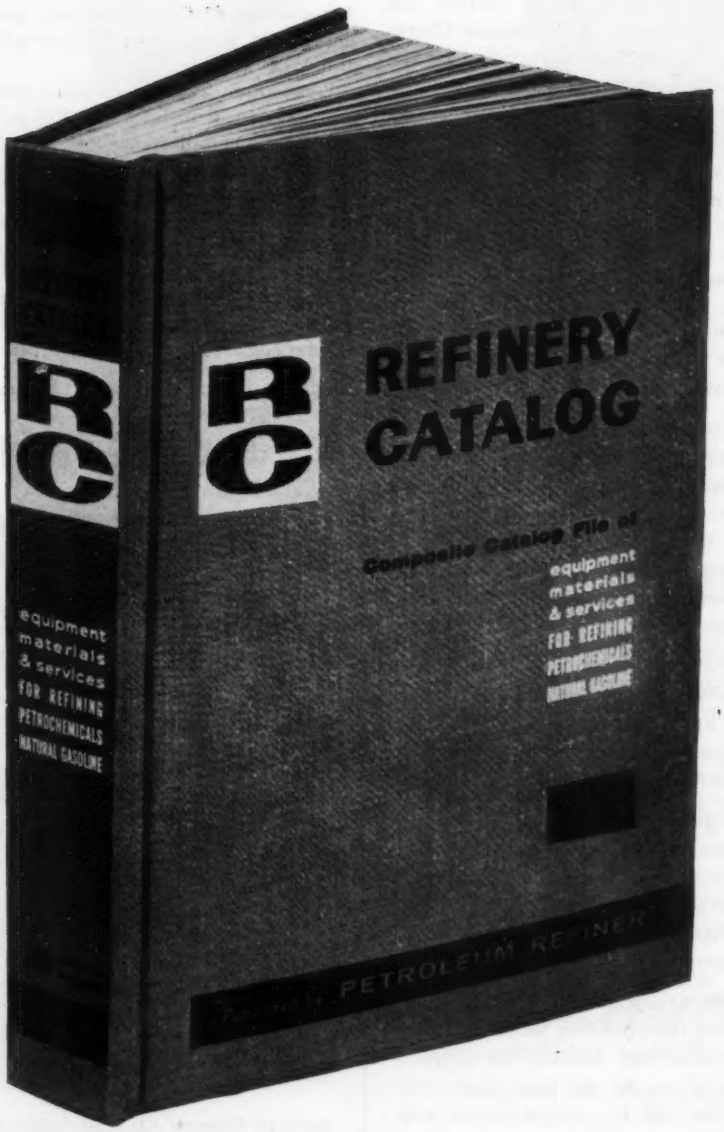

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Who's Building...

carbon fractionation plant and storage facilities at Siloam, Ky. and a products pipeline to transport the liquid hydrocarbons to the site. This project will cost about $5 million.

The Fluor Corp., Ltd., Los Angeles, recently raised the lower half of the fluid coker reactor-fractionator at the complete refinery the engineering-construction firm is building for the Pontiac Eastern Corp. at Purvis, Miss.

When completed in October, the 11,000 barrels per day facility will be the largest in Mississippi. Its total cost will be approximately $20 million.

The fluid coker vessel will be 156 feet, 8-inch seam to seam by 160 feet I. D. at the center section, and will stand about 187 feet above grade. The vessel was field assembled from six shop fabricated sections and erected in two pieces with the final weld to be made in place.

In addition to the fluid coker the refinery will have a TCC unit, distillate fractionator, gas plant, sulfuric acid alkylation unit, Unifiner, Platformer, treating plant, and sulfur plant.

With the exception of the office and laboratory Fluor is also handling all offsite work.

Farmers Union Central Exchange, Billings, Mont., has announced plans for construction of three new units at its Laurel, Mont. refinery. A contract for construction of a 4400-bpd naphtha Unifining unit, a 5100-bpd Platforming unit, and a 7100-bpd middle distillate Unifining unit has been awarded to The Refinery Engineering Co. of Tulsa, division of the Vitro Corp. of America. Treco completed a catalytic cracker for FUCE in 1952 at the Laurel refinery.

The naphtha Unifiner will remove sulfur, metals and other contaminants from the Platformer feed stock. This will improve operation of the Platformer as well as the quality of the Platformed gasoline. The Platformer will produce high octane gasoline components from this stock. The middle distillate Unifiner will also remove sulfur and other undesirable elements to produce highest grade middle distillates.

Construction of the units, licensed by Universal Oil Products Co., will begin this month and is scheduled for completion early in 1958.

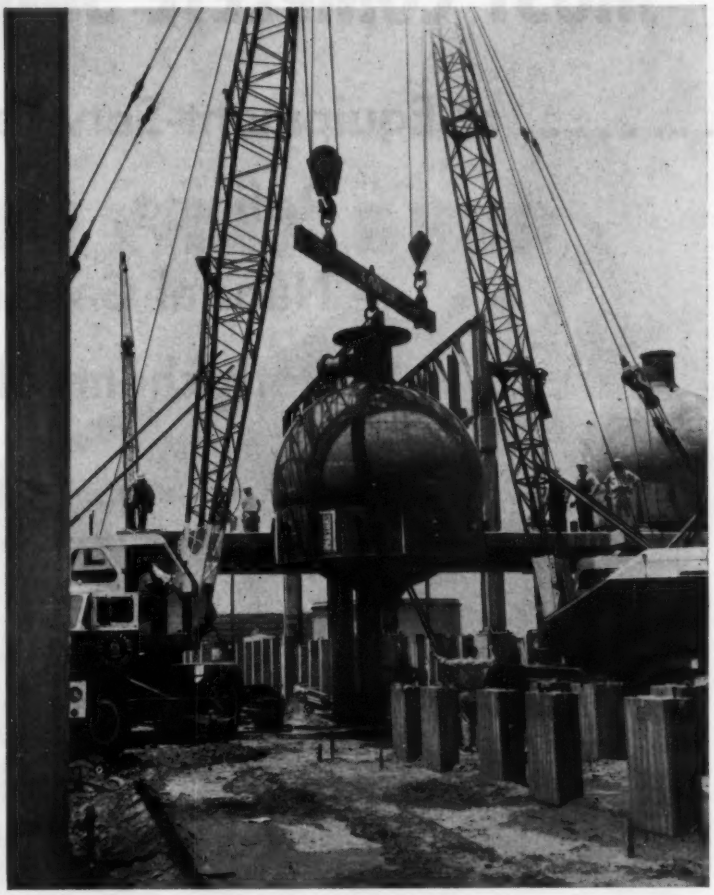
American Independent Oil Co. will help to finance the 22,000-bpd refinery to be built at Emden by Erdoelwerke Frisia AG.

The latter company was recently formed by Swiss marketer Gottlieb Duttweiler. Amoinoil has heretofore supplied crude from its production in the Saudi Arabia-Kuwait Neutral Zone to Duttweiler's cutrate marketing organization in Switzerland.

Under an agreement disclosed recently, Aminoil will supply Neutral Zone crude for the projected plant at Emden. Paul Conrad, Duttweiler's general manager in Germany, confirmed that Amoinoil will also invest "quite a large sum" in construction of the plant.

Two German oil companies are expected to participate with Amoinoil and Duttweiler's Swiss marketing organization in partial financing of the refinery.

Giant 'Mushroom' Moves In



One of three spherical reactors at the new catalytic reformer being built at General Petroleum Corporation's Torrance refinery is raised by two cranes for setting on foundations. Each reactor is about 20 feet high and weighs 100,000 pounds. These vessels will be set on roller bearings to permit travel when attendant piping expands.

Harry Bass & Sons, Dallas, are one step closer to building a multi-million dollar gasoline plant and repressuring system for the giant Pembina field of Alberta. This came about as the result of a hearing before the Alberta Oil and Gas Conservation Board which indicated approval of a proposal by Harry Bass & Sons calling for a central plant in the heart of the field, a pipeline network, and a number of compressor stations.

The only things that stand in the way now are a few legal changes, and the final approval of Alberta Premier E. C. Manning and officials of the Mines and Minerals Department.

Part of the $17 million project would involve a 100 Mmcfd gasoline plant which would be built at a cost of $2 million. It would turn out about 200,000 gallons of liquid products daily with the output being divided evenly among butane, propane, and natural gasoline. It is thought that the plant will be completed in either late 1958 or early 1959.

Union Carbide Corp., will build a chemical plant in Putnam County, W. V. The new facilities will produce basic chemical products to meet the growing demands of industry.

The new plant, to be completed in 1960, will be the eighth major chemicals producing plant of the company. D. B. Benedict, president of Union Carbide Chemicals Co., division of Union Carbide Corp., which will operate the plant, commenting on the new venture, said: "We already have two major plants for the production of organic chemicals in this region. The new facilities will produce chemicals for the market and supply raw materials for further processing at the South Charleston and Institute plants."

The ethanol produced in the new facilities will be used as a raw material and sold for use by industry as a solvent or extractant in the manufacture of lacquers, disinfectants, and pharmaceuticals. Ethanol from this plant will be shipped to other plants of Union Carbide Chemicals in the Kanawha Valley where it will be the feed

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Who's Building . . .

material in operations for the production of other finished chemicals.

Ethylene oxide is another major product to be produced in the new plant. The new facilities initially will add 150 million pounds per year to Union Carbide Chemicals Co.'s capacity for ethylene oxide production. Ethylene oxide will be shipped to South Charleston and Institute for the production of several oxide derivatives in facilities already in place there. One of the important derivatives is ethylene glycol, the base for Prestone brand anti-freeze.

The plant site is on the south bank of the Kanawha River, near the town of Winfield, county seat of Putnam County. The river provides process water for steam and cooling. Suitable dock installations will make possible the fullest use of water transportation.

Leonard Refineries, Inc., Alma, Mich., has unveiled a multi-million dollar expansion program which calls for a 7500-bpd fluid catalytic cracking unit to upgrade fuel oil to extra high octane gasoline, and a 43-mile pipe line to a new Lansing terminal.

A contract has been signed with The Ralph M. Parsons Co., Los Angeles, for the construction of the catalytic cracker. It is anticipated to be completed in August, 1958.

Greatly increased demands by the motoring public for Leonard quality fuels brought about the expansion program, shareowners were told.

"Leonard Refineries' high standards of quality products and modern equipment are always foremost in mind," company spokesmen told the gathering.

Raffineria di Roma will build a new refinery at Rome, Italy, to process about 30,000 barrels of crude daily. The new plant will replace an older one separated by Purfina Italiana. Raffineria di Roma was formed at the end of 1956 with Purfina Italiana, a Petrolfina group member, and ENI sharing ownership on a 50-50 basis. Also terminal facilities for 45,000 ton tankers are to be built. During 1956 Purfina Italiana's Genoa and Milan refineries were further modernized, and the Florence refinery was shut down permanently.

Purfina Mineraloel Raffinerie, A. G. has been formed as a new Petrofina affiliate to build and operate a new refinery at Duisbourg. The new company was formed early in 1957. During 1956, the Ruhrbau refinery was shut down for modifications. The new Duisbourg refinery is slated to have a capacity of 20,000 bpd, to be increased later to about 60,000 barrels daily.

Polychem, Ltd., has started production at the first polystyrene plastic manufacturing plant in the middle east and southeast Asia. It is located in Bombay, India.

About a year in construction, the new plant is owned by Polychem, Ltd., formed in 1955 by The Dow Chemical Co. and Kilachand Devchand & Co. Ltd., an Indian firm.

Dow supplied the technical know-how for production, as well as technical assistance in designing and equipping the plant.

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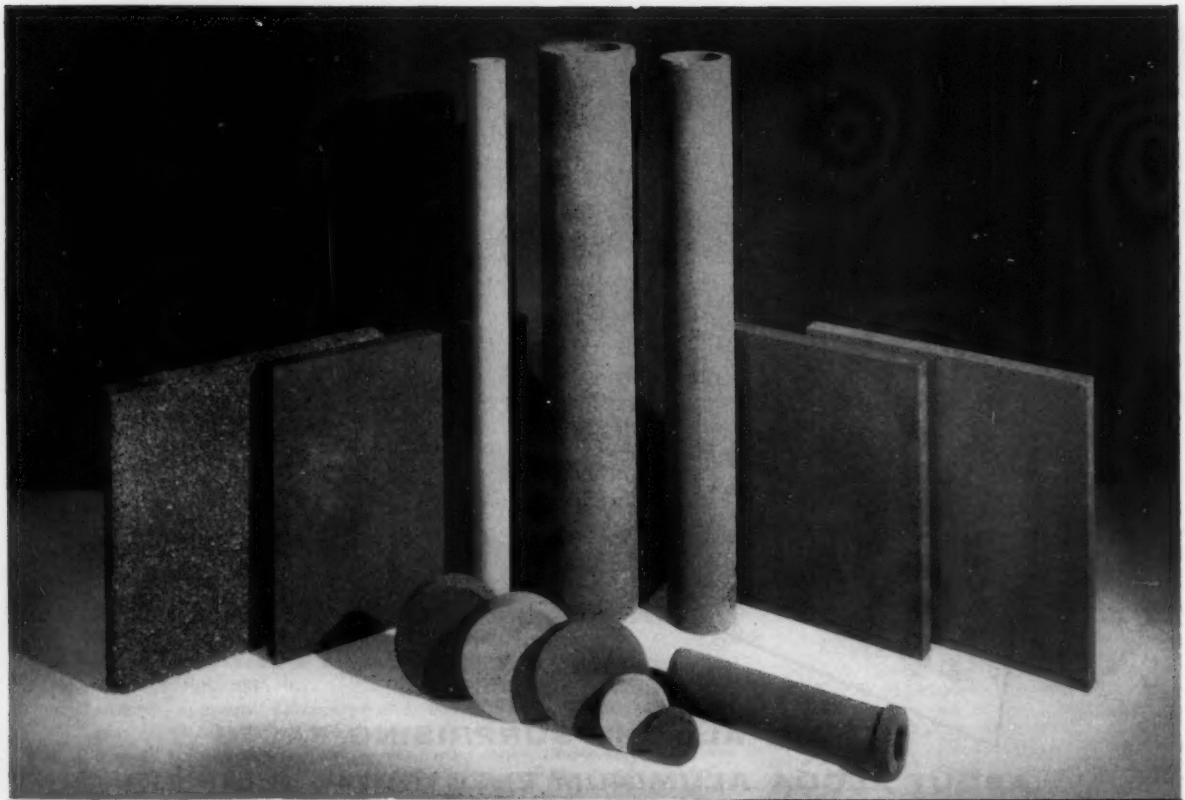

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It also has provided training for Indians comprising the key operating personnel. Fifty percent of the company's common stock is held by the Indian public while Dow and Kilachand group share its remaining stock.

Kilachand Devchand is an organization with wide interests in insurance, banking, the sugar and chemical industries, shipping, and the automobile and engineering industries.

Anglo-Ecuadorian Oilfields, Ltd., has commissioned Procon (Great Britain) Ltd., to build a new refinery at La Libertad. The new capacity will make Ecuador self sufficient in refined products by mid-1958 and is part of an agreement made last year between Anglo-American and the Ecuadorian government. Lobitos Oilfields, Ltd., and South American Gold and Platinum Co. are the majority stockholders in Anglo-Ecuadorian. Design work on the new refinery is being done by Universal Oil Products, Ltd.

Monsanto Chemical Co. has begun two major expansions of the capacity of its petrochemical production facilities at Texas City. A 40-million-pound increase in the rated capacity of the styrene monomer plant will be completed by June, 1958, and that a 12-million-pound addition to the plant's acetylene capacity will be completed early in 1958. Acetylene is one of the basic raw materials for the manufacture of acrylonitrile and vinyl chloride monomer, both produced at Texas City.

By-product gas from acetylene process is the principal raw material for the Monsanto-operated methanol plant jointly owned with Heyden-Newport Chemical Corp.

Who's Building. . .

Shell Oil Co. has awarded a contract covering the design, procurement and erection of its previously announced 16,000-bpd combination UOP Platforming-Unifining unit at its Norco, La., refinery to Procon Inc.

The combination Platforming-Unifining unit will be one of the largest of its type ever built. Shell officials said the Platformer will be designed for high severity operation.

Construction is expected to be completed in 1958.

Dow Chemical Co. of Canada has purchased 400 acres at Sarnia, Ont., as a possible site for future expansion. Company has no immediate plans for building on the location though.

Standard Oil Co. (Indiana) has announced a multi-million-dollar modernization and expansion program at its Wood River refinery.

Louis H. Butterworth, refinery manager, said two major new refinery facilities will be built soon to help the company keep up with customer demand for its improved, higher-octane gasolines and other petroleum products.

Announced for immediate construction are a 67,500-bpd crude oil distillation unit and a 30,000-bpd fluid catalytic cracking unit.

"When completed early in 1959," Butterworth said, "the new facilities will increase the Wood River refinery's crude oil

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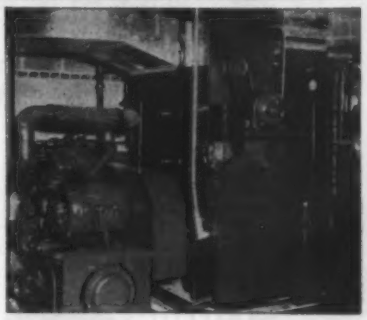

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Who's Building . . .

processing capacity by about 30 percent."

Arthur G. McKee Co., of Cleveland, has been selected as prime contractor for the new facilities, site preparation will get under way soon, and construction is expected to begin within about three months.

Crude oil distillation, thermal and catalytic cracking, and vapor recovery facilities now in use at the Wood River refinery will be retired from service after the new facilities are in operation, Butterworth said. The coking batteries are now idle.

Construction work under the 1957 Wood River refinery modernization and expansion program will follow by 50 years the building of Standard Oil's original Wood River refinery, begun in the fall of 1907. Refinery operations at Wood River began late in 1908 with a crude oil processing capacity of about 7500-bpd.

British Petroleum and **Farbenfabriken Bayer** plan a joint company for making petrochemicals. Construction on some units is already under way on a site adjacent to Bayer's Dormagen Germany plant. Eventual investment may come to about $60 million. The 300,000 tons of feedstock will come from BP's new refinery to be built in the Ruhr area. Output will be organic intermediates.

Panama Refining & Petrochemical Co., Inc., has selected the site where it will construct its previously announced 55,000-bpd refinery. The location will be at Portobelo Harbor, 15 miles northeast of the Caribbean entrance to the Panama Canal.

The $33 million refinery will be built on an abandoned U. A. Air Force emergency landing field next to the village of Portobelo in the state of Colon. Selection of the site was one of the final details to be settled before construction could begin. Work on the plant is scheduled to start shortly.

An executive order by Panamanian President Ernesto dela Guardia, Jr., gave the company the necessary 360-acre tract. President Guardia also signed a decree making the harbor an international port.

Portobelo is one of the world's finest natural harbors, and the water is deep enough to allow entry of just about any type of vessel.

The two financial men are the owners of Panama Refining are Eugene Du Pont III of Wilmington, Del., and John M. Shaheen of New York. An independent American refining company will operate the refinery for them.

Shaheen, who is president of the firm, says that they have signed contracts with several major U. S. oil companies for a ten year supply of crude oil and for the entire output of the refinery for the next ten years.

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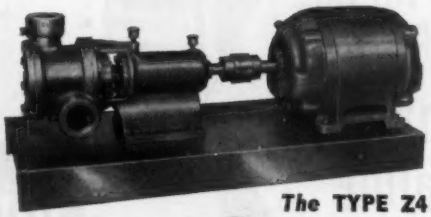

The TYPE Z4
AURORA® APCO *Process* PUMPS

WRITE *for* BULLETIN 111-ZA

AURORA *Always* PUMPS

You are urged to get acquainted with this complete answer to many of the most difficult pumping tasks of modern industry. The characteristics of the most advanced turbine-type pump, the APCO, combine with special new design features, special metals where required to insure SURE RESULTS. May we tell you more?

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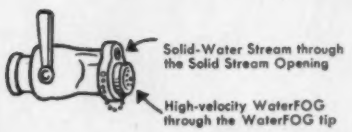
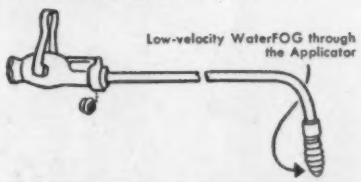
EXPORT DEPARTMENT — Aurora, Illinois — Cable Address "NYABINT"

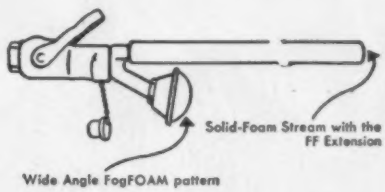
Rockwood SG-60 WaterFOG Nozzle is five nozzles in one

The lightweight Rockwood SG-60 WaterFOG Nozzle *eliminates "special" or single-purpose nozzles!* It actually does the work of five nozzles to put out fires faster, safer and more economically.

Here's what we mean . . .

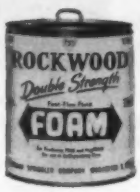






Here's what you need to put out ordinary combustibles and flammable liquids . . .

FOAM and "Wet" Eductor with the new FW Metering-Check Valve. Introduces Rockwood FOAM or "Wet" into hose lines, automatically proportioning correct amount of FOAM and "Wet" to water. Also usable wherever one liquid is fed into another on a fixed percentage basis.



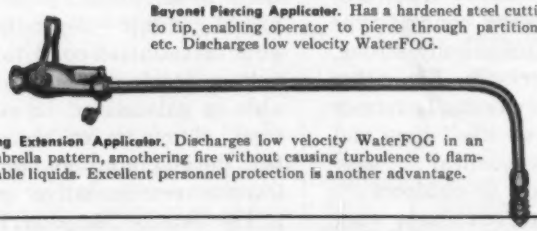
Rockwood Double Strength FOAM. Puts out fires in flammable liquids, and in ordinary combustibles, quicker, at lower cost. Three parts FOAM and 97 parts water create a heat-resistant blanket.

Rockwood WET. One part WET mixed with 99 parts water increases water's penetration and extinguishing action. Gives quickest results against deep seated fires. Saves time, water, manpower.

FF Extension Unit. Shown with Type SG-60 Nozzle. Discharges Rockwood FOAM in a solid stream or as Fog-FOAM. Wide angle makes it possible to cover large areas at one time.

and here's the way to get more information

Bayonet Piercing Applicator. Has a hardened steel cutting tool attached to tip, enabling operator to pierce through partitions, into interiors, etc. Discharges low velocity WaterFOG.



Long Extension Applicator. Discharges low velocity WaterFOG in an umbrella pattern, smothering fire without causing turbulence to flammable liquids. Excellent personnel protection is another advantage.

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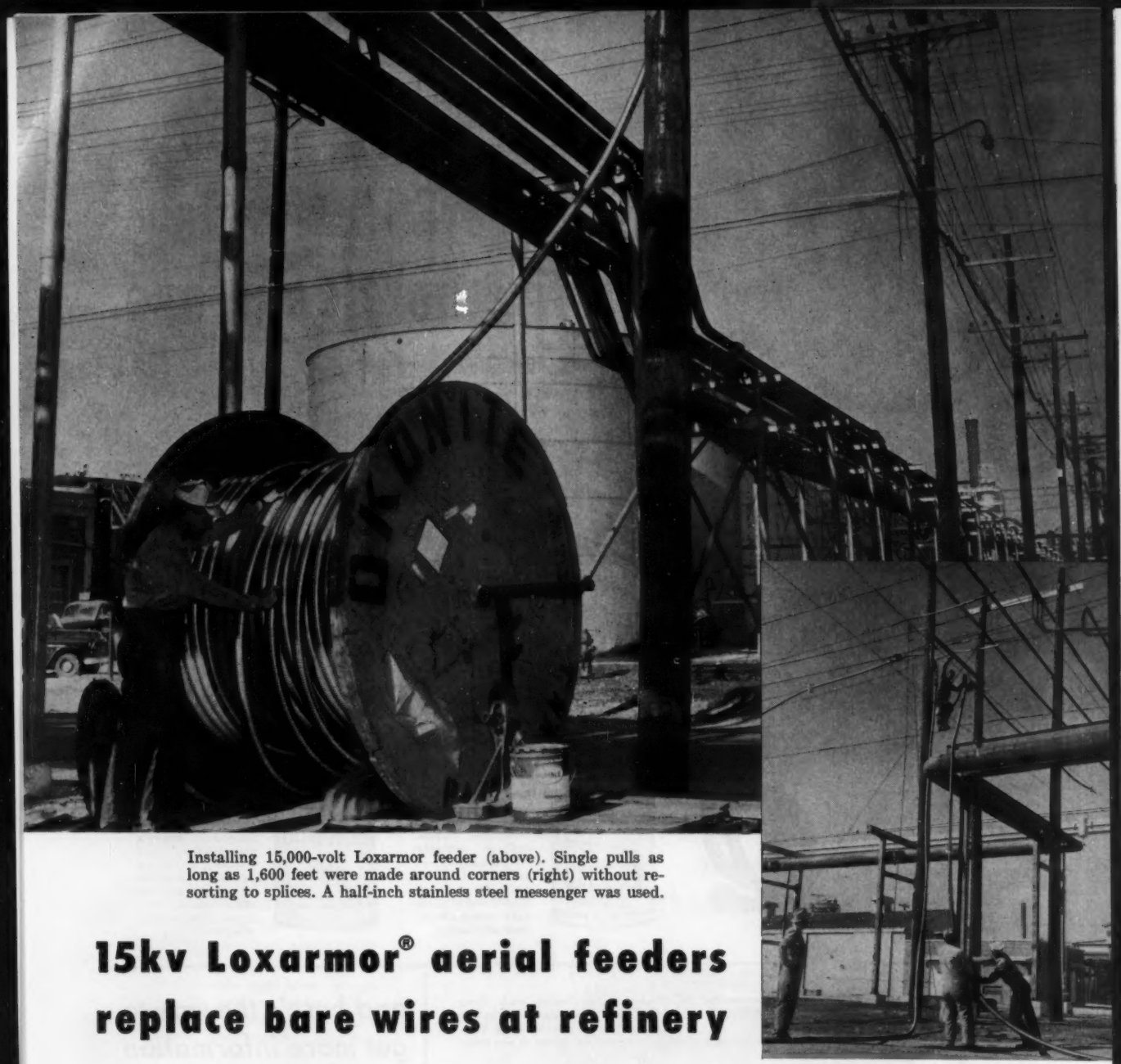

Installing 15,000-volt Loxarmor feeder (above). Single pulls as long as 1,600 feet were made around corners (right) without resorting to splices. A half-inch stainless steel messenger was used.

15kv Loxarmor® aerial feeders replace bare wires at refinery

In replacing bare wire aerial feeders that had proved unreliable in bad weather and had, on several occasions, shorted out and burned down, a Texas refinery installed nearly 8,000 feet of Okonite oil-impregnated, paper-insulated, lead-sheathed Loxarmor cable. Protected with an interlocking S-shaped bronze armor (Loxarmor), this cable has proved itself 100% reliable. The Loxarmor provides mechanical protection against movable drag lines, cranes, and the like.

Here is one example of how industry uses versatile Loxarmor cable—the modern conduit-type cable that's mechanically strong, flexible and versatile. For either power or control circuits, Loxarmor cable has proved itself time and again to be economical . . . easy to install indoors or outdoors . . . easy to move and re-route . . . easy to inspect and maintain . . . completely reliable and dependable.

Loxarmor can be supplied over any standard Okonite insulation, rubber, plastic, paper or varnished cambric—depending upon your installation conditions and voltage requirements. It is available in galvanized or stainless steel, aluminum or bronze. For full details, contact your local Okonite representative or write to The Okonite Company, Passaic, New Jersey.

where there's electrical power... there's **OKONITE CABLE**

4845

Who's Building...

whereby no income taxes will be levied on exports, including shipments to the Canal Zone for the next 25 years.

Foster Wheeler Corp., New York, is the prime contractor.

Canadian Husky Oil Ltd. has announced a major expansion program for its refinery at Fort William. Contracts have already been awarded for additions to the plant which will cost nearly $700,000. Construction is scheduled to get underway this fall.

Units to be added include a new Diesulformer, storage tanks, water tube boilers and expanded facilities for handling crude oil and products.

Canadian Husky purchased the Fort William refinery late in 1954 and in 1956 completed the initial program of modernization and expansion.

The Diesulformer to be installed will be one of only a few such units in Canada. The process of hydrogenation of intermediate products which it uses is a comparatively recent development in petroleum refining. Canadian Husky was one of the first companies in Canada to make use of the process when it installed a Diesulformer at its Moose Jaw refinery in 1955. The Fort William installation will have a capacity of 1000 bpd.

Three new storage tanks, each capable of holding 1.4 million gallons, and the new handling equipment will permit Husky to achieve a better balance in year-around operations at the Lakehead.

Poole-Pritchard, Ltd., was awarded the contract for installation of the Diesulformer and Sparling Tank and Mfg., Ltd. will construct the tanks.

The new facilities will not add to the throughput capacity of the refinery, now rated at 4000 bpd. They will permit emphasis on higher quality rather than increased quantity of products.

Societe Belge de L'Azote et des Produits Chimiques du Marly (S.B.A.), Liege, Bilgium, has received a contract from the Italian company ANIC for the planning and construction of a styrene monomer plant based on the plans, process information and know-how supplied by Koppers Co., Inc.

The plant will be installed in Ravenna and will have an annual capacity of 14,000 tons of styrene.

The styrene will be used for the production of synthetic rubber in a plant which is actually under construction.

This is the third styrene monomer plant that S. B. A. has constructed in Europa according to the process information supplied by Koppers Co., Inc. The first installation of this type is, since 1956, operated in Mazingarbe (Nord) by the French company Ethyl-Synthese while the second one is in operation by Houilleres du Bassin de Lorraine in Carling, Moselle.

The Wilshire Oil Co. of California has placed the latest in petroleum platforming equipment on stream at its Norwalk refinery. The unit, a Platformer-Unifiner, has a capacity of approximately 400,000 gallons per day of high octane gasoline and will enable Wilshire to make premium grade motor fuels for high compression engines Anderson stated.

Thirteen months in construction, the unit is one of the largest on the Pacific

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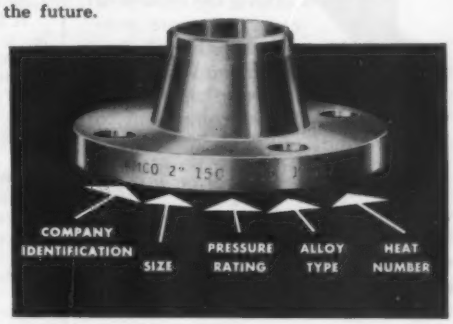
All Camco ASA flanges have a heat code imprinted allowing positive identification with specific material used and covered by certificates of analysis on file. This information can be supplied on request without charge.



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below 800° F.

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Type LT-840
Low temperature Xactemp Pyrometer with rigid extension arm and surface tip thermocouple.

1001 USES

This is the answer to quick, accurate temperature readings below 800° F. in many industrial processes and operations. And it's so convenient to handle.

The Xactemp hand-type pyrometer, Model LT-840, is used with needle thermocouples, ribbon thermocouple, surface tip thermocouple, and other specially designed thermocouples and extension arms. These are easily interchangeable and, without adjustments or recalibration of the instrument, quickly ready it for measuring the surface temperature of stationary and revolving rolls and cylinders, flat and irregular surfaces of molds, dies, etc. in rubber and paper making, plastic materials, rubber, wax, oils, greases, and other semifluid materials.

Handy, compact design makes this Xactemp pyrometer ideal for field service, laboratory, and production-line use.

Write for detailed, descriptive literature on Gordon Xactemp Pyrometers.

5645

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Who's Building . . .

Coast and cost in excess of $3.5 million. It is operated under license from Universal Oil Products Co., and was built by Southwestern Engineering Co.

Petroleo Brasileiro (Petrobras) is expanding its Mataripe refinery from 6000 to 37,000 bpd at a cost of $50 million. The refinery is near Salvador in Bahia.

New facilities of the Metaripe refinery, first placed in operation in 1951, will include two crude distillation units created by revising existing thermal cracking units; atmospheric and vacuum-distillation units; catalytic cracking, propane deasphalting, and phenol solvent extraction units, and extensive lube and wax processing units.

United Refining Co. has placed two new units on stream at its 8500 bpd refinery at Warren, Pa. The units are a 2500-bpd. fluid catalytic cracking unit and a 230-bpd polymerization plant. Both units were designed, engineered, and licensed by Universal Oil Products Co.

Utah Oil Refining Co., will spend $16.2 million over the next 5 years to expand its Rocky Mountain interests. Included in the program is a capacity increase of 6000-bpd at its 30,000-bpd Salt Lake City refinery.

A $2,125,000 contract has already been let to Fluor Corp., for a 35,000-bpd pipe still at the plant. The present still would go on standby. The expansion will also take in bulk plants and service stations. Slightly less than half the money is allotted for these facilities.

Premier Oil Refining Co. has completed a $1.5 million expansion at its Longview, Texas refinery. Latest installation to go in was a 1500-bpd Platformer and Unifiner unit. The plant earlier increased crude capacity from 4200 to 4700 bpd and added 300 bpd of thermal-processing capacity. Premier is a wholly owned subsidiary of City Products Corp., Chicago.

Imperial Chemical Industries, Ltd., has started up a second large-scale carbonoxylation plant at Billingham, England. The plant will make butanols, to be consumed mainly by the paint and lacquer industry. This second plant increases ICI's butanols output seven times. The carbonoxylation process, known also as the oxo process, is not used on such a large scale anywhere in the world as it is at Billingham.

Ben Franklin Refining Co. will build a 1000 bpd hydrofluoric alkylation unit (UOP license) at its Ardmore, Okla., refinery. Construction of the unit which is licensed by Universal Oil Products Co., will be by The Refinery Engineering Co.

Copetrol Oil Refining Co. S.A. expects to have its 15,000 bpd export refinery in operation within a year on Cuba's east Coast. The refinery will be built in Nuevitas, Camaguey province. Its initial capacity will eventually be increased to 33,000 bpd.

Final plans have not as yet been completed. No arrangements have been con-

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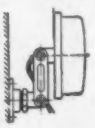
Dial Thermometers now in three types to suit any requirements

PATENTED

Full 4½" dial face. Stem can be placed at any angle and case can be rotated to any readable position.

1 **Rigid Stem Dial Thermometer** tapered bulb, interchangeable with standard industrial thermometer separable socket. (As illustrated above.)

2 **Wall Mounted Dial Thermometer** with flexible connecting armor. Case adjustable to easy reading position.



3 **Flush Mounted Dial Thermometer** for panel mounting with flexible connecting armor.

All three types have a full 4½" dial face.

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensaton. Guaranteed Accurate 1 scale division.

for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

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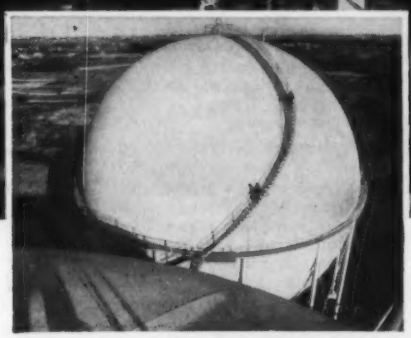
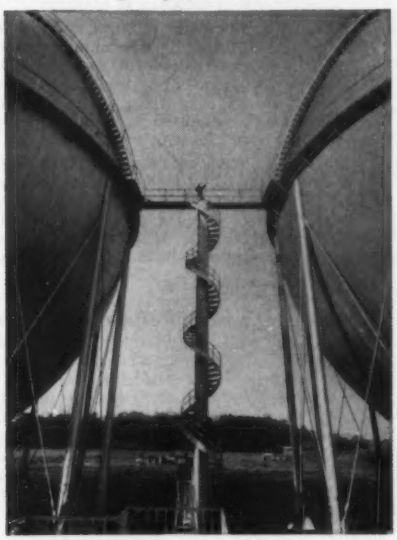
IN TOKYO, JAPAN

WORLD'S LARGEST USS "T-1" STEEL PRESSURE VESSELS

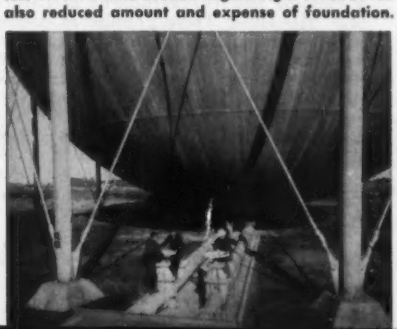
Beyond the Shinto shrine are the two USS "T-1" Steel spheres. They are being used by Tokyo Gas Works, Ltd., for the storage of natural gas at a pressure of 71.1 psi.



Lightweight construction—made possible by USS "T-1" Steel—cut shipping, handling and erection costs of these giant pressure vessels.



Thinner walls meant less weld metal required, less erection time needed. Lightweight construction also reduced amount and expense of foundation.



COMPARED TO CARBON STEEL CONSTRUCTION, the use of USS "T-1" Steel saved 1,720 tons of steel in the two giant pressure vessels pictured here. Having a diameter of 110.5 ft. each, they are the largest Hortonspheres ever built for the storage of gas. USS "T-1" Steel enabled Chicago Bridge & Iron Company to use 0.73-inch-thick shell plates rather than mild steel plates 1.75 inches thick.

USS "T-1" Steel's very high yield strength (90,000 psi minimum), plus previous experience in building non-code government vessels, permitted use of a maximum allowable working stress of 36,000 psi to which a 90% weld joint efficiency was applied. With the exception of the working stress values, the vessels were built to the ASME Code for Unfired Pressure Vessels where applicable.

In addition to saving 1,720 tons of steel, the thinner USS "T-1" Steel plates drastically lowered the cost of shipping to Japan. And each ton saved meant lower erection, welding and foundation costs. Added up, all these savings point out why the use of USS "T-1" Steel spells economy.

Shell plates were fabricated at CB&I's Greenville, Pa. plant and shipped to Tokyo for field erection. Field welding was done with E 12016 electrodes and did not require stress relief. All welds were 100% X-rayed.

Two additional vessels of similar design, but smaller in size, are now being fabricated by Chicago Bridge & Iron for installation in Tokyo.

USS "T-1" Steel is being used to improve performance and reduce costs in a wide variety of applications in steel mills, in mining equipment, in construction equipment, in materials handling equipment, in bridges, and even in steam turbines. Write for complete information about its application and fabrication. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

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UNITED STATES STEEL

Watch the **United States Steel** Hour on TV every other Wednesday (10 p.m. Eastern time).

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(MESH ENTRAINMENT SEPARATORS)

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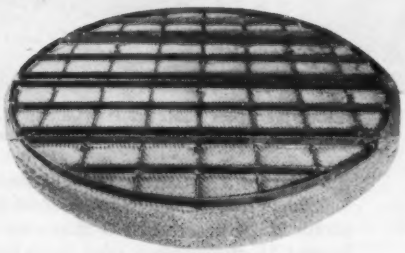

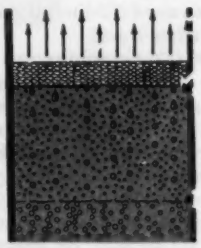

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Who's Building . . .

cluded for crude purchases or products sales. Grebe & Doremus Process Co., Houston, is expected to design and build the plant.

Copetrol has an authorized capital of $20 million. Financing is understood to be principally American. According to Cuba Petroleum News Digest, Copetrol is an outgrowth of a company formed earlier by two Florida businessmen to build a 5000 bpd plant in Las Villas Province.

Humble Oil & Refining Co. will spend about $1.5 million to expand its Houston, research center.

Escambia Chemical Corp. is building a 50,000 square feet research center in Wilton, Conn., to conduct research in petrochemicals, plastics and related fields.

Surpass Petrochemicals, Ltd. last month placed on stream its new $1-million petroleum sulfonates plant at Sarborough, Ont.

Northwest Nitro-Chemicals, Ltd., is already planning to sink $150,000 into expansion at its 6 month old, $22 million fertilizer plant at Medicine Hat in southern Alberta. Plant is now at capacity: ammonium nitrate 35,000 tons per year; ammonium phosphate, 65,000 tons per year; ammonium phosphate-sulphate, 42,000 tons per year.

Sinclair Oil & Gas Co., has announced that the installation of a deisobutanizer at Gas Products Plant No. 6 at Covington in Garfield county, Okla., is planned.

The new unit will separate isobutane from normal butane. The isobutane is used as refinery charge stock for making high octane motor fuel. The product will be delivered by refinery truck. The normal butane will be shipped to customers by tank car.

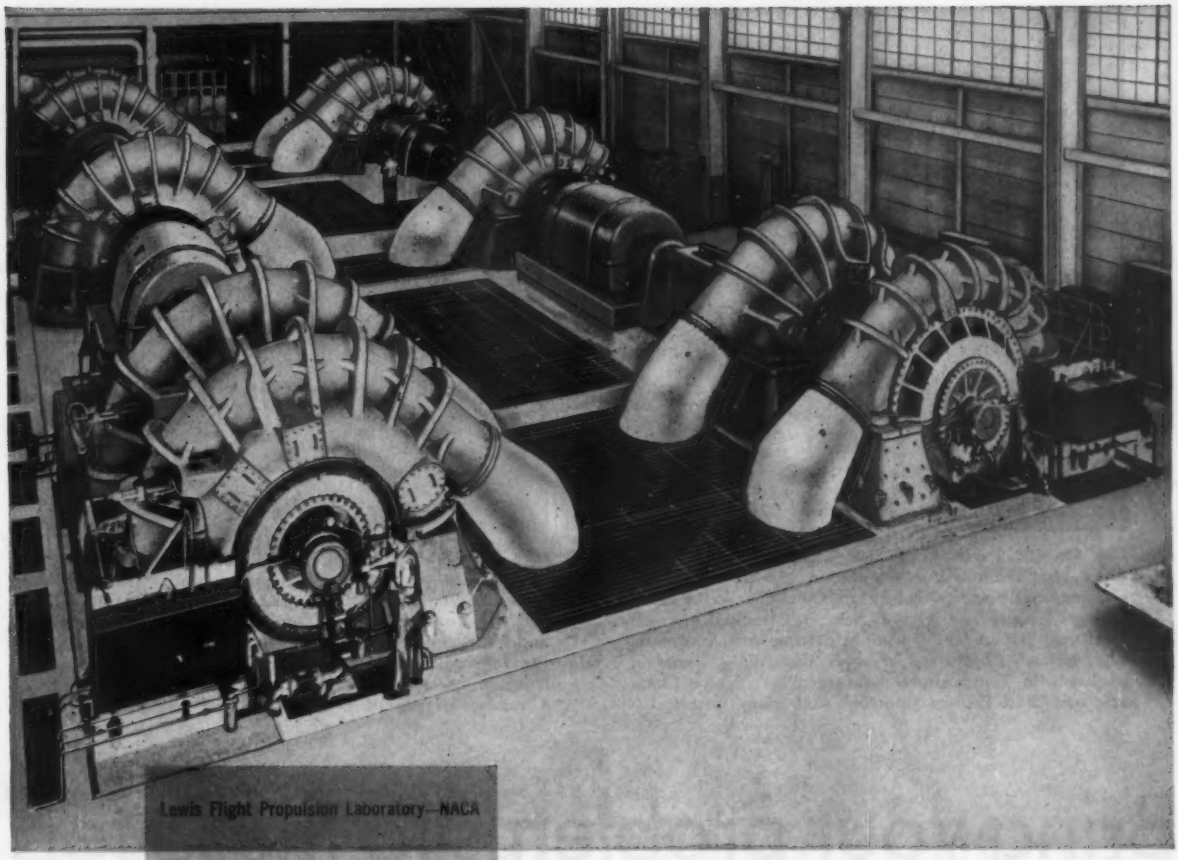
Charge capacity of the deisobutanizer will be 20,000 gallons per day. It is cheduled to be in operation by January 1, 1958.

The Covington plant processes 18 million cubic feet of gas daily, and total production of all products is 55,000 gallons daily.

Commerce Oil Refining Corp.'s long discussed 30,000-bpd refinery for Rhode Island's Narragansett Bay area is still indefinite. Local residents are objecting to construction of the $45 million plant. Navy Dept, too, "prefers" that it be built elsewhere because of proximity to Navy's torpedo testing station. Final decision may be made at high levels in Washington, though construction is set to start Sept. 1.

Societe Naphthachimie, France, is building new installations at Lavera near Marseilles. These promise to double ethylene and propylene production and to make possible 4000 additional metric tons of polyethylene per year. Another polyethylene plant, that of Manufacture Normande de Polyethylene, is near completion at Gonfreville. This will go on stream at the beginning of 1958. It will produce 10 tons per day initially; plans call for raising this to 16 tons per day by the end of the year.

For more data on advertised products, use Readers' Service Cards, last page.



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How one of the world's largest wind tunnels can help a refinery man!

Roots-Connersville supplies a complete line of air and gas handling equipment . . . centrifugal, Spiraxial® and rotary positive blowers, exhausters and compressors . . . rotary positive gas pumps and meters . . . rotary vacuum pumps . . . for manufacturing and process industries.

From violent, roaring cyclones of air to silent, almost perfect vacuums . . .

atmospheres "in the mass" are created and precisely controlled to order by these giant Roots-Connersville centrifugal blowers at Lewis Flight Propulsion Laboratory in Cleveland, Ohio.

In solving unusual air and gas handling problems such as this, Roots-Connersville draws on a highly developed engineering and manufacturing skill. For over 100 years, R-C equipment has been meeting the most exacting requirements of industry around the world.

Roots-Connersville, one of the Dresser Industries, will be glad to put its broad knowledge and experience to work for you. Your problem will receive immediate attention from our Application Engineering Department.

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J. G. ZIEGLER, Pacific Coast Sales Engineer, a member of the Taylor Team of Instrumentation Scientists, is known internationally in his field. Together, the well-known team of Ziegler and Nichols have collaborated on such published papers as "Optimum Setting for Automatic Controllers," "Industrial Process Control," "Dynamic Accuracy in Temperature Measurement," "Valve Characteristics and Process Control," and many others.

N. B. NICHOLS, Chief Engineer, Taylor Instrument Companies, also has an international reputation as an instrumentation scientist. He was called to MIT during the war to work in the servomechanisms laboratory and later as group leader of the fire control division of the radiation laboratory. He edited a book on servomechanisms, and along with John Ziegler has authored a number of papers on the science of process control.

Bring your problems to these top

GEORGE E. HOWARD, Manager of the important Application Engineering Department of Taylor Instrument Companies, has had over 20 years experience in the design and application of engineered control systems, specializing in the Chemical, Petroleum and Textile Industries. During World War II Mr. Howard trained Government personnel on instrument operation and maintenance at the Government's Oak Ridge Atomic Energy Plant where Taylor was the prime contractor on instrumentation.

RICHARD N. POND, Vice President of the Instrument Society of America and a member of the Executive Board, has served the society in a variety of capacities since he first became active in the St. Louis chapter in 1946. He was secretary, and later chairman, of the committee on Instrumentation for Production Processing. He is a Divisional Sales Manager for his company, specializing in Oil Refining, Petrochemicals, Brewing, Power, Rubber and Plastics.

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Fundamentals of Safety and Fire Protection

These are the ingredients you need for an effective safety and fire protection program.

J. L. Risinger
Consultant
Maplewood, N. J.

FIGURE 1—The three-legged stool shown above represents the eight ingredients needed for an effective safety and fire protection program.

MOST SCHOOLS OF THOUGHT are agreed upon the chief fundamentals of an industrial safety program. These fundamentals have not been evolved by any individual program—they have grown into being as a result of need.

Studying results obtained by different companies over many years, it is observed that those firms which have maintained extensive and intensive inspections and guarding programs, and whose housekeeping have been among the best, have had some of the highest accident records. Others, mediocre in this phase of the program but carrying other phases on a balanced basis, have had better records.

As a result, management conference groups usually come up with the conclusion that the most successful accident and fire prevention program is one balanced as on the legs of a three legged stool (see Figure 1), containing provisions for obtaining and maintaining:

A. Correct attitude of supervisors and workmen, maintained so by incentive and promotional plans, organized so as to enlist both supervisors and workmen into the safety program on a sound basis, and cause their acceptance of full responsibilities for their own and fellow workers' safety, and for the prevention of damage to property by accident and fire.

B. Supervisors and workmen trained in safe and correct planning and performance, and maintained so by a constant training program designed and carried out in a manner to obtain safe and correct procedures, operations and activities at all times and under all conditions.

C. Safe environment in which to work, maintained so by keeping machinery equipment and location safe, and good housekeeping correct.

These three provisions, strengthened by correct organization, company policy and acceptance of responsibility by members of management and employes, provide an outline of fundamentals with which to overcome the causes of accidents in the oil industry.

The essentials of an effective safety program have been analyzed by many conference groups, both at the head office and in the field. Programs based on the findings of these groups have been instituted for entire companies, as well as individual units. (See Figure 2.)

The groups have usually concluded that an accident is simply the result of an error somewhere along the line; that if these errors continue to occur someone is invariably injured or a fire occurs. In any case, errors are contrary to successful operation regardless of whether anyone is injured.

It is obvious that tools, machinery and the powers of service are controlled or caused to act a certain way by people. Therefore, all or most all accidents can be traced back to some point of human failure. It is also recognized that some companies place too much emphasis on the environmental or mechanical aspects of safety, and not enough on the possibilities of human failure.

Continued on Next Page

Fundamentals of a Safety Program

To give all the findings of one safety conference on fundamentals would fill a booklet, even in outline. However, a general approach is outlined below:

A. To obtain and maintain correct attitude toward a safety program, the following suggestions are offered:

1. Attitude must start at the top and work down, i.e., the enthusiasm company personnel show toward safety will be in direct proportion to the attitude of top management.
2. Establish a well defined company policy.
3. Use the right approach. Wanted by managers and supervisors assistance, not policing.
4. Make sure channels of responsibility are well established.
5. Make proper use of accurate statistics:
   a. On bulletin boards.
   b. In monthly releases.
   c. In supervisory groups.
   d. By recognizing outstanding safety records.
6. Organize participation on an individual basis.
7. Publicize safety whenever and wherever possible:
   a. Publicize outstanding records in local newspapers, and employe publications.
   b. Include "safety at work" in plant newspapers.
   c. Special safety columns in employe publications.
   d. Promotional ideas, such as contests, promoted by all company communications media.
   e. Special letters, bulletins and letters from management.
   f. Establish recognition plans.
8. Maintain safety enthusiasm through promotion in management and employe safety committee meetings.

B. To obtain and maintain leaders trained in correct and safe planning, and workmen trained in safe performance, the following suggestions are offered:

1. Include safety in all training programs. This includes orientation programs for new employes, as well as for experienced personnel.
2. Include safety in all job instruction manuals.
3. Train foremen in the use of protective equipment.
4. Train foremen in the conference method of holding meetings.
5. Prepare and promote the use of safety manuals.
6. Management safety committees. Employe safety committees.
7. Special training in characteristics of petroleum and its products, and fire prevention and control. (See Figure 3.)
8. Train employes to control fires at work locations.
9. Train crews to fight fires in accordance with what is burning, and in the most effective use of equipment provided.
10. Train men in the correct procedure in operation of regular equipment.
11. In refineries, train employes to use blow down equipment, correct use of valves, etc.
12. In producing and drilling, train employes to use controls such as blow-out preventers, etc.
13. Develop safe working practices.
14. Train supervisors to plan safety into each job before it starts.
15. Set up an effective first aid training program.
16. Training in health, sanitation and safe use of company facilities.
17. Train employes in use of company communications equipment in time of emergency.

FIGURE 2—Safety programs are more effective when local management participates in its building. Shown above is a program being planned by the use of the conference method.

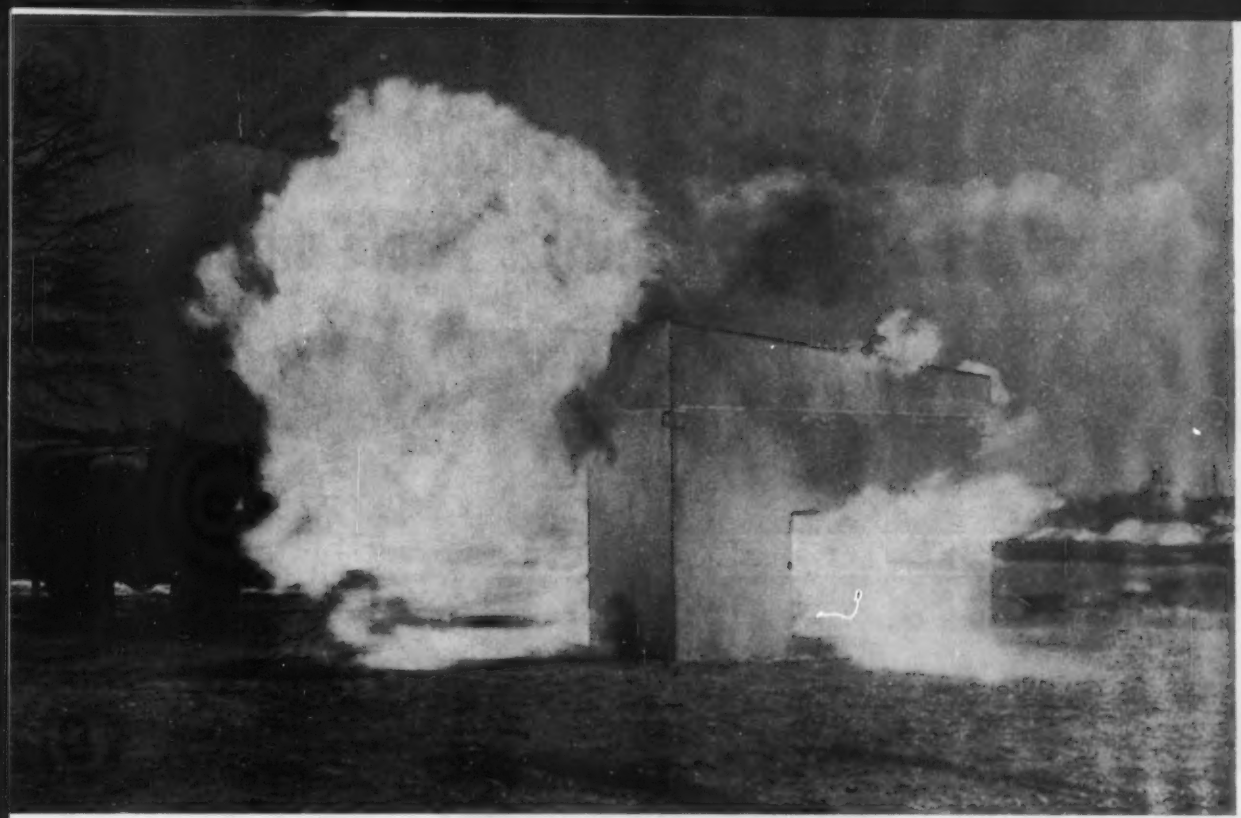

FIGURE 3—Field demonstration set up to teach employes and the public never to use gasoline for cleaning purposes.

C. To obtain and maintain a safe environment in which to work, the following suggestions are offered:

1. If all of the attitude and training features are operating smoothly, the safe environment in which to work will invariably come about.
2. Check all plans and specifications for safety before construction, remodeling or adapting any plant, building, structure or part thereof.
3. Careful periodic check of buildings.
4. Careful periodic check of machinery, guards, tools and equipment.
5. Good housekeeping program.
6. Safety and fire protection engineering in design, layout, construction and operation.
7. Correct arrangement of working areas.
8. Provide workmen with conditions that are conducive to job pride, efficiency, and lack of frustration.
9. Provide suitable personal protective equipment.
10. Give particular attention to equipment procured or remodeled for a new process.
11. Careful check of used machines or equipment put back into service.
12. Provide suitable lighting.
13. Provide suitable sanitation facilities.
14. Check and maintain rigging equipment that is suitable and of adequate strength.
15. Make sure that heating, ventilating and exhaust systems are correct and adequate.
16. Provide safe exits, railings, stairways and walkways.
17. Provide safe elevators, cranes, derricks, hoists, conveyors and lifting equipment to eliminate heavy manual strain.
18. Make all mechanical devices and equipment as efficient and safe as possible, premises safe, and human relations courteous and cooperative.

A Sample Company Safety Policy. In 1934, the board of directors of a major oil company adopted the following resolution regarding company safety policy:

"It is the policy of this company that employes shall have a safe place in which to work, safe tools with which to work, and safe methods by which to work."

This was a good and purposeful policy. It was really a guarantee to employes, and it obtained results, however, much better results have been obtained since 1942. During that year management in the field worked out and added to the resolution the enacting clause by placing on themselves:

"That safety and fire protection and the carrying out of company policy respecting them, is a responsibility of each member of management, both line and staff, commensurate with the scope and authority of the job of each."

In the conferences in which this management evaluated its responsibilities, safety was organized into and as a part of each operation, procedure, activity and relation under the jurisdiction of each. Also, that in each case from top to bottom, the president, director, manager, superintendent, foreman or other members of management are responsible for all of the accidents and fires that could have been prevented by their forethought.

Organization was set up to link safety into, among and between all operations, procedures, responsibilities,

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activities and relations, as a responsibility of every representative of management and labor commensurate with the scope and authority of the job of each. Policy worked up in conferences with groups from the board of directors to gang leaders was based on a well defined purpose of such importance as to merit the personal attention of top-most executives and call for action at all levels.

To develop the policy and organize the team in a manner to be of the greatest assistance to those who would carry their own respective programs to a common objective, all members of management participated in establishing the objective as well as the development of policy. Accordingly in foremen conferences, all levels of management not only placed their own responsibilities and established their own programs, but also worked out what each thought the objectives should be and what the policy and channels of responsibility of the department as a whole should be.

After each series of conferences the accident rate dropped in a vast majority of cases, at least 50 percent in two years. In each annual series of review conferences, the findings on what the department's policy and channels of responsibility should be, were also reviewed.

The policy and channels of responsibility outlined below are essentially those worked up by more than 500 members of management in safety conferences:

Accident and Fire Prevention Policy

A. It is the policy of this company:

1. To maintain in every phase of operations and activities, a continuous balanced and effective safety and fire prevention program which will insure:
   a. An informed and constructive attitude on the part of all personnel toward safety and fire protection.
   b. Supervisors trained in safe planning of work and employes trained in safe performance of work.
   c. Safe working conditions.
2. To foster participation in accident and fire prevention by all employes, both individually and collectively, while at the same time leaving with management complete control of and responsibility for this work.
3. To make accident and fire prevention a genuine part of every operation and activity under its jurisdiction.
4. To maintain the principle that accident and fire prevention authority and responsibility is to be delegated to all individuals in a managerial or supervisory position to a degree commensurate with their operation authority and responsibility.
5. To carry out accident and fire prevention work through the normal lines of authority established for an organization's regular operation.
6. To provide specialized service and advice on safety and fire protection as a staff function to all managers, superintendents and others in charge of equipment or property, or supervising workmen.

Channels of Responsibility

1. Full responsibility for effective accident and fire prevention is that of management.
2. Responsibility for accident and fire prevention is to be delegated in the same manner and degree as operating responsibility.
3. Administration of accident and fire prevention is to be conducted through the same channels of authority and in the same manner as all other business of the organization.
4. Service (staff) departments are responsible not only for accident and fire prevention within the department, but also in connection with all services rendered.
5. Persons given full or part-time responsibilities to specialize in accident and fire prevention are to be well trained and qualified in this function. In the performance of their work, such individuals are "staff," not "line." That is, they have no authority or responsibilities for operations, but are advisers, planners, and general assistants in their specialty for "line" (operating) management.
6. The man in charge of a given operation, whether he be manager, superintendent, foreman or other type of supervisor, is responsible for all accidents and fires that occur in this department if they could have been prevented by his forethought. (This applies to office organizations as well as all others.)

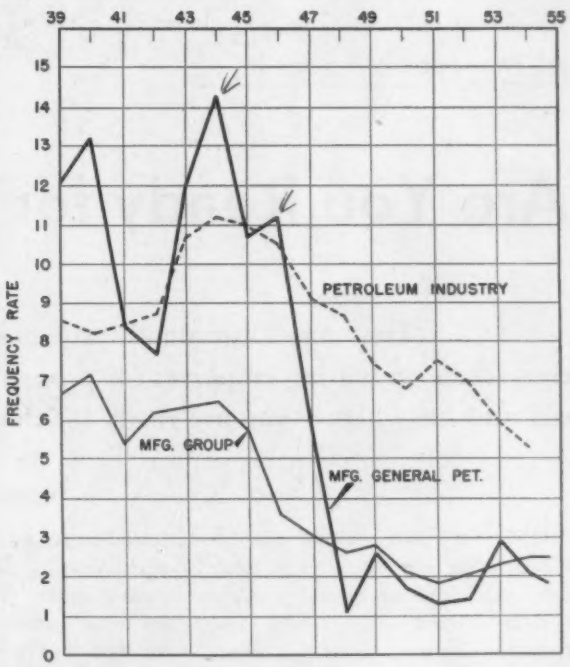
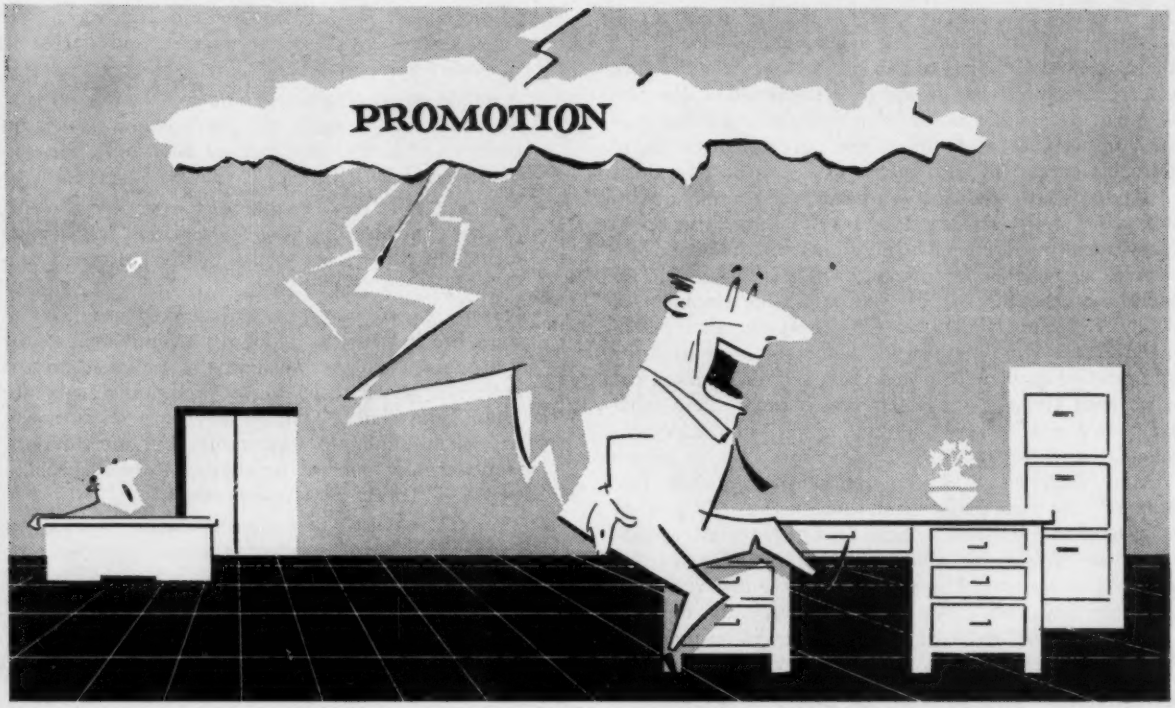


FIGURE 4—This is what one company accomplished by setting up a safety program following the principles outlined in this article. Key to success: Safety men do not demand cooperation, but give it to those in charge.

The result of safety programs based on the above policy and channels of responsibility is reflected by the charts shown in Figure 4.

How to organize an effective safety and fire protection program will be the subject of the next article in the series, to appear in the October issue of PETROLEUM REFINER.



As Management Sees It . . .

Are You Ready for 'Lightning' to Strike?

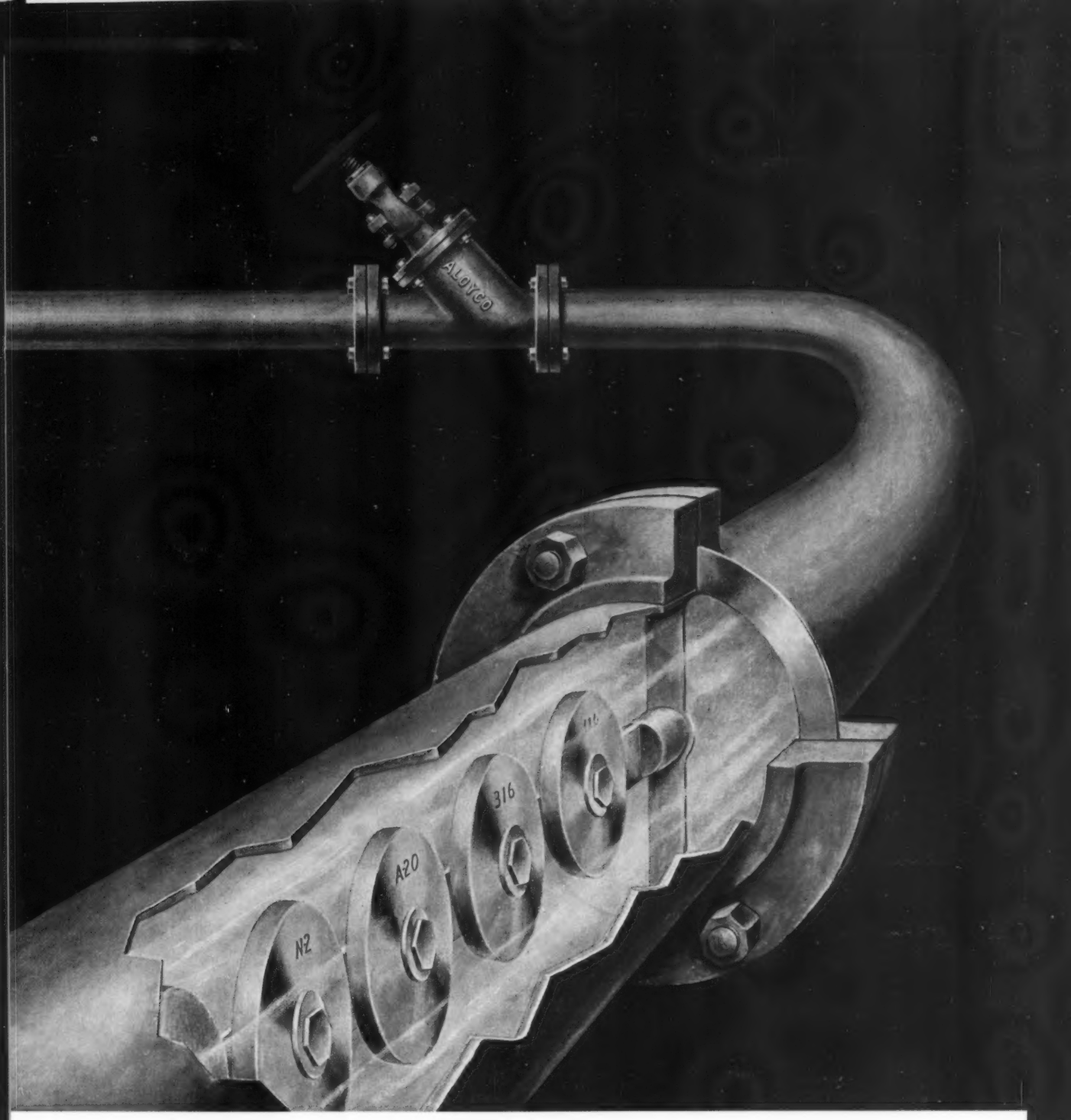
Here are 50 personal traits most often considered when evaluating employes for promotion. Rate yourself and see whether you are ready for the 'bolt' to strike.

ONE OF THE toughest assignments facing any executive is to decide which one of several employes is to be selected for promotion. Aside from the desire to be as fair as possible he must also be certain that the best possible man from the standpoint of value to the company will be selected.

Here is a method being used by a number of executives not only in the refining industry but in other fields as well. They use a promotion check chart such as that shown in the accompanying illustration. Each factor is balanced for the individual under consideration as to positive possession, uncertainty or failure to possess the desired quality. Two points are scored for those in the first column and one for those in the second (none for the negative checks). The various totals arrived at for each of the employes being checked serve to spotlight the individual possessing the best potential for the new staff position.

Points to be checked vary from one refinery to another. We have selected herewith 50 of those which appeared most often in a wide number of such lists studied. The reader may use all or any number since different factors will apply to different staff positions under consideration. Keep your own score and see how you rate.

1. Keeps quality of present work exceptionally high day in and day out.
2. Is continually improving his own knowledge of the refinery operation.
3. Knows what to do in average situations without being told.
4. Has always been willing to share in unpleasant work or unpleasant aspects of the job with other employes.
5. Is good at routine; has shown a knack for following established patterns.
6. Is not fixed in his ways of doing things and has shown willingness to alter previously established methods.
7. Has the ability to learn new methods and shown positive interest in doing so whenever possible.
8. Has demonstrated orderliness in his present work.



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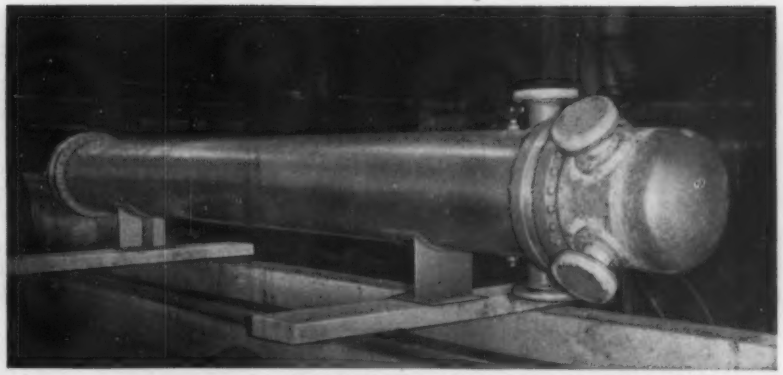
9. Possesses adequate knowledge of details of his present job.
10. Has shown a definite interest in receiving a promotion and wanting to climb in the company organization.
11. Requires a minimum of instruction for any ordinary work assignment.
12. Can think things out—does not need minute detailed explanation of what to do on every assignment.
13. Has shown no inclination to "goof off" at the job now held.
14. Has a good record of past work performance not only with the refinery but on previous jobs.
15. Takes good care of his personal health in private as well as on the job.
16. Has a record on the present job of a minimum of errors of judgment.
17. Can do every regular assignment without needing close supervision.
18. Does not give alibis or excuses for failure to do his work.
19. Has a general attitude of cheerfulness at his present job and around others.
20. Shows seriousness at his work; has demonstrated a minimum of "horse play."
21. Can do his present job without physical or mental strain.
22. Demonstrates patience with others in connection with his work; both those above him and at his own level in the organization.
23. Is able to pro-rate his energies throughout the day and keep at top efficiency all through.
24. Has demonstrated a positive interest in the refinery business in the past.
25. Has demonstrated loyalty to the company in the past.
26. Knows how to get along with supervisors in his present job.
27. Possesses the ability to concentrate on a given problem and solve it effectively in a minimum of time.
28. Seeks and does additional tasks connected with his job without their being assigned directly to him.
29. Is respected by the men and women with whom he has worked.
30. Can stand criticism from su-



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Over-All Length: 16' 1"
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Test Pressure: Shell Side, 150 psi—Tube Side, 300 psi
Design Temperature: Shell Side, 250° F.—Tube Side, 350° F.
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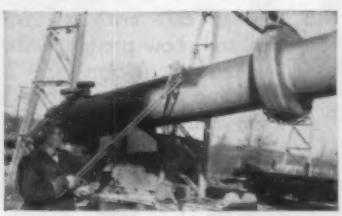

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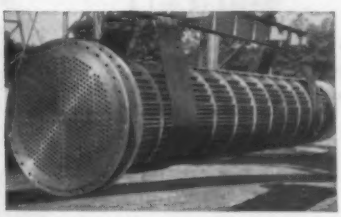

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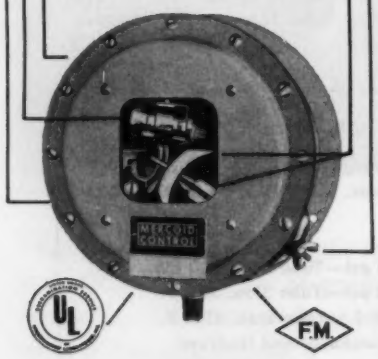

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1			
2			
3			
4			
48			
49			
50			
Totals	____ x2. - ____	____ x1 - ____	____ P plus N. ____

The above chart may be used in analyzing each individual with respect to points set forth in the accompanying article. The number of lines used will be determined by the number of points applicable. As an example, if all 50 are used and 38 checked positive, that would total 76 in the first column; 10 checked in the second column would give a score total (P Plus N) of 86 since the remaining 12 in the third column would carry no score.

periors as well as fellow employes without being hurt or showing resentment.

31. Is usually pleasant and cheerful as a natural personality trait.

32. Willingly conforms to the rules set for employe conduct.

33. Does not become flustered or embarrassed easily.

34. Has personal long range plans for his career and has worked toward them in the past.

35. He can take criticism given to him and show profit thereby following such criticism.

36. Is willing to accept responsibility when things go wrong on the job.

37. Has pleasant personal habits and traits.

38. Is settled in his personal life away from the job and in relationships with others.

39. Is able to work with and get along with both sexes among employes.

40. Has no fixed prejudices in his personal thinking.

41. Has learned all of the basic fundamentals of his present job and shows possibility of doing so easily on the job under consideration.

42. Has full appreciation of the principle that the refinery must make a profit and how it is done.

43. Lives within his means and successfully manages his money problems on his present income.

44. Has the necessary background and education to handle the next step up the ladder.

45. Has developed good outside interests in his life to offset any job tensions which develop in his work.

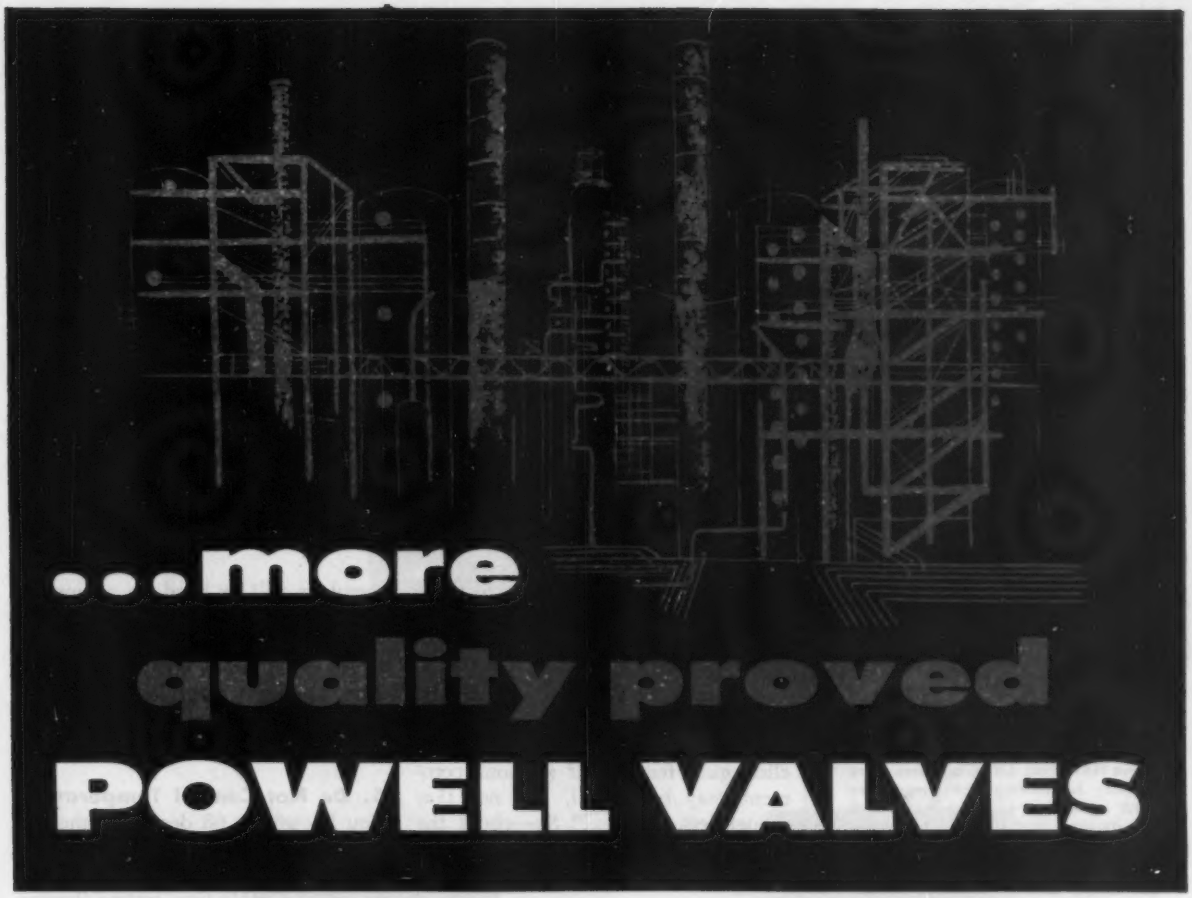
46. Has demonstrated willingness to help others who lack his own capabilities.

47. Has demonstrated self confidence and assurance both on and off his present job.

48. Has refrained from obvious apple polishing; a sign of personally admitted shortcomings.

49. Has expressed confidence in the firm as being a fine company.

50. Has shown no signs of unstableness in political or economic thinking in the past. ##



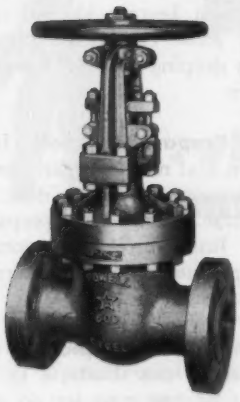
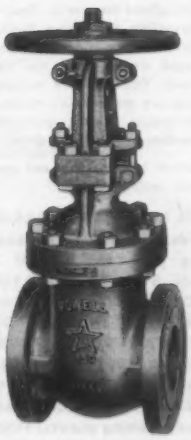


FIG. 6003 SS—Alloy Steel Gate Valve for 600 Pounds W.S.P.

FIG. 3061—300-Pound Steel Swing Check Valve.

FIG. 1563G—Gear Operated Lubricated Plug Valve, 150 Pound Steel.

FIG. 1503—150-Pound Steel Gate Valve.



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OIL BURNERS and GAS BURNERS for industrial power, process and heating purposes; STEAM ATOMIZING OIL BURNERS; MOTOR-DRIVEN ROTARY OIL BURNERS; MECHANICAL PRESSURE ATOMIZING OIL BURNERS; LOW AIR PRESSURE OIL BURNERS; GAS BURNERS; COMBINATION GAS and OIL BURNERS; AUTOMATIC OIL BURNERS, for small process furnaces and heating plants; FUEL OIL HEATERS; FUEL OIL PUMPING and HEATING UNITS; FURNACE RELIEF DOORS; AIR INTAKE DOORS; OBSERVATION PORTS; SPECIAL REFRACTORY SHAPES.

CHEMICAL PETROLEUM DIVISION

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INDUSTRIAL OIL BURNERS, GAS BURNERS, AND FURNACE EQUIPMENT

As Management Sees It . .

How to Ruin a Meeting

Check these 25 "rules to ruin" for a meeting leader. Some may apply to you!

J. Damon Quinton
Consulting Psychologist, Houston

THERE ARE many ways to make a staff meeting unsuccessful. Listed below are a few sure-fire "rules to ruin" for the meeting leader.

You may not have been as extreme in your actions as these indicate, but there may be some rules here that elicit guilt feelings. If so, your comment may be, "Well, I'm not *that* thoughtless, but . . ." So—check the ones that you have guilt feelings about and seek to correct *your* "rules to ruin."

1. Send Notices Two Months in Advance. This will allow the notice to be misplaced and forgotten. At starting time on the day of the conference, your secretary will have to call about half the participants. This will use up at least one hour of your time. Those who came on time get bored and restless. Latecomers are confused and apologetic.

2. Do Not Check Meeting Room. Especially if the meeting is to be held at a new location. More than likely the place will be uncomfortable, unpleasant and disagreeable. This will put a damper on discussion. You, the leader, will be under a strain. Perspiring, wiggling participants will add to your discomfort.

3. Be Late for Meeting. And have the only key to the conference room. Let the men stand around in the hall. That helps to ruin the conference.

4. Let Group Arrange Own Chairs. This will guarantee a poorly arranged and scattered group. Most of the members will be lined up against the back wall. Friends will sit together in huddles and talk in loud stage whispers throughout the conference. That large, forbidding space between the leader and the participants will add to the downfall of the meeting.

5. Do Not Control Temperature. You know that 68 degrees is the best temperature to have at a conference but darned if you're going to spend all your valuable time setting thermostats. Besides, if the temperature is high the men become sluggish and won't ask those embarrassing questions. "Let sleeping dogs lie" is a good motto here.

6. Don't Prepare Yourself. It is well known that most company meetings fail because the leader does not prepare himself. Don't bring prepared questions. Just "throw the meeting open." Everyone will just sit there in the awkward silence.

7. Be Ignorant of Topic. In this way the leader can illustrate to the group that he can consider no subjects that are not specifically covered in the leader's guide. To help this "rule to ruin" along, the leader can bluff his way through embarrassing questions. The result? Why, the leader will lose all the prestige he ever had.

8. Introduce Subject in Long, Stilted and Biased Manner. By the time you finish this lecture type of introduction the participants will not understand the topic and will not know the problem to be solved. The

You'll save time and trouble on H.P. VESSEL GASKETS

...when J-M Goetze gasket specialists make them for you

When you need gaskets such as those above, which were made for pressure vessel service over 5000 psi, consider this. It takes less time and trouble to turn the job over to J-M Goetze —an organization that has specialized in gasket design and manufacture for 67 years. And it usually costs less in the long run.

Goetze engineers can select the right style for maximum sealing efficiency. They know the correct metals and other factors required for efficient, long-lasting gaskets.

Goetze Gaskets are made exactly to the last detail of your specifications and conditions. They are made to craftsmen's perfection . . . with modern machine tools, some of which were specially designed by Goetze for gasket manufacture.

If you need gaskets for high pressure vessels or similar applications, send us a drawing or template for quotation. Or write for further information to Johns-Manville, Box 60, New York 16, New York.

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Johns-Manville PACKINGS, GASKETS and TEXTILES

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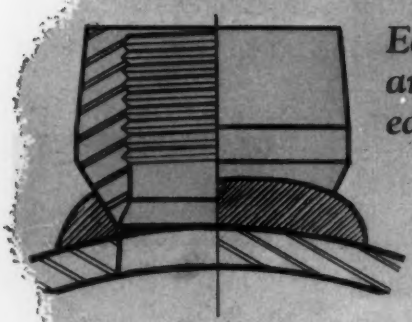
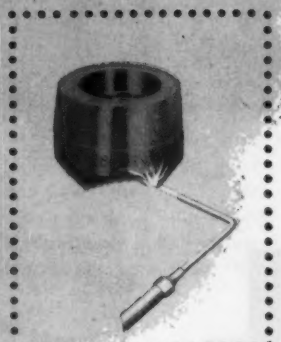


Economical and easy-to-install



Readily modified for small diameter installation

W-S Couplets are designed to function as universal outlet connections for tanks, process vessels and pipelines. They eliminate the need for large, expensive field inventories and costly delays in fabrication.

On most tank, and large piping installations they are used as received. On those few applications where attachment is to be made to a small diameter pipe, the W-S Couplet is easily modified by contouring the welding end with an acetylene torch to mate with the curvature of the pipe diameter. Couplets are made with extra length and heavy wall to permit contouring without detriment to the threaded or socket end.

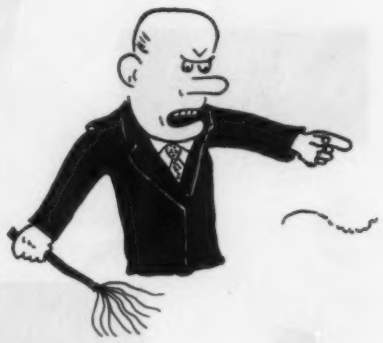
W-S Couplets are available in sizes ¼" through 2", with screw-end or socket-welding dimensions ... also in a 90° elbow.

Send for Bulletin CP-1-57. Write to W-S Fittings Division, H. K. Porter Company, Inc., P. O. Box 95, Roselle, N. J.

H. K. PORTER COMPANY, INC.

W-S FITTINGS DIVISION

rest of the meeting time can then be spent with the blind leading the blind. A splendid disrespect for meetings can be built up in this manner.



9. Dominate the Group. The more the leader talks the less the participants talk. The members will begin to resent the leader's implication that he is the only one there with enough brains and experience to solve the problems. They feel useless and soon the session has turned into a "one man's opinion" affair.

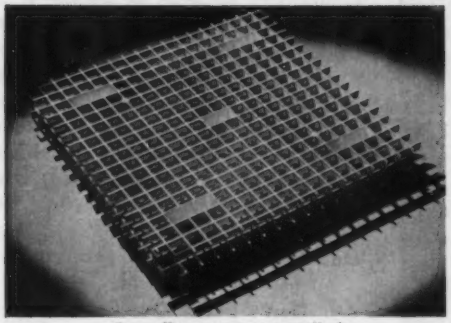
10. Use Formal Language. This will create a stuffy atmosphere and dampen discussion. The participants will soon feel that the leader is "stuck up."

11. Alternative: Establish Informality Quickly. This can be accomplished by using profanity and telling dirty stories. You will find that you have succeeded in losing the respect of the group. Your meeting is now on the way to a howling failure.

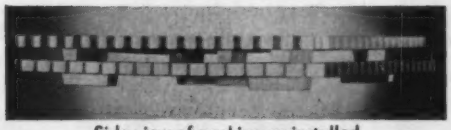
12. Let a Few Members "Hog" Discussion. The best thinking of the group is not brought forth. If you do try to break this monopoly, do it di-

announcing

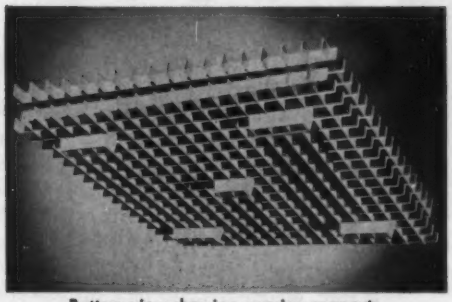
FLUOR'S NEW *poly-* GRID



Overall top view as installed



Side view of packing as installed



Bottom view showing spacing supports

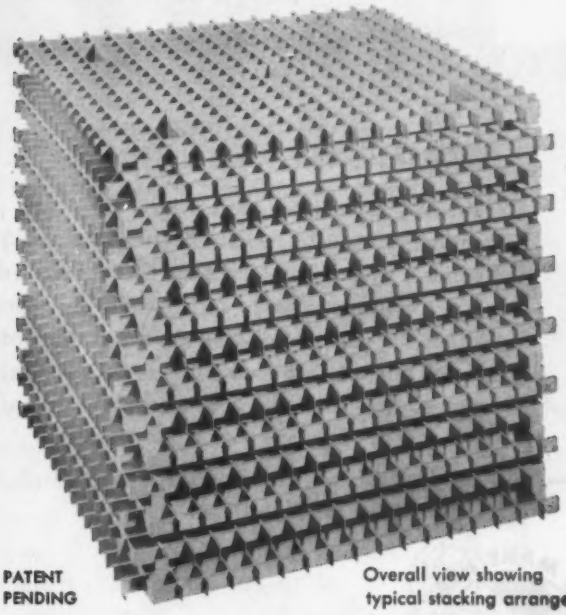
MORE COOLING IN YOUR EXISTING TOWER . . .

To increase the throughput of your existing counterflow induced draft cooling tower, Fluor Products Company now offers "Poly-Grid" packing.

This revolutionary packing provides greater cooling surface — greater overall heat transfer; yet construction is open, and pressure drop low.

"Poly-Grid" is available in high impact polystyrene or linear-polyethylene to meet all water conditions.

Fluor "Poly-Grid" packing allows you to cool more water under existing operating conditions, or to realize extra cooling of present throughput — all at minimum capital expenditure.



PATENT PENDING

Overall view showing typical stacking arrangement

Contact your nearest Fluor Representative for details.

POLY-GRID can be easily installed in any counterflow induced draft cooling tower—regardless of make or model!

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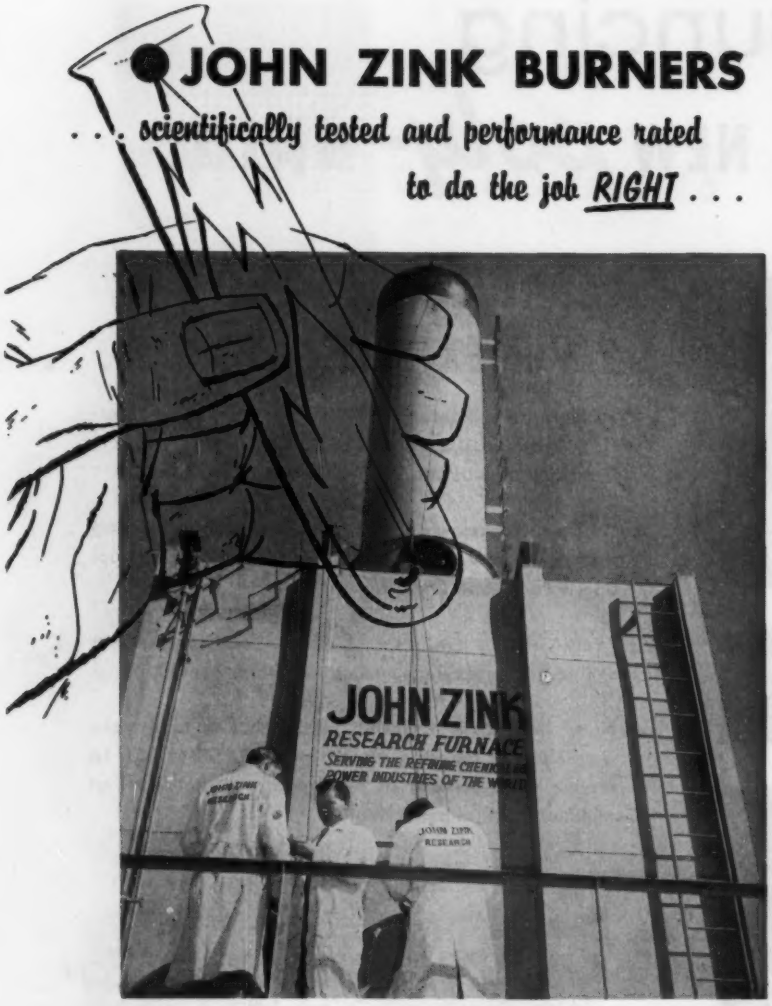

This research furnace affords an ideal proving ground for design changes in standard lines of burners, as well as enabling the John Zink Company to find *workable* solutions to new problems. In this way the John Zink Company can offer you special burners for your individual application . . . burners that have been *performance tested* before they reach your job site.

→ *The facilities of the John Zink research furnace are available to industry.*

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If you have a specialized industrial burner problem . . . JOHN ZINK has the answer . . .

JOHN ZINK COMPANY

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rectly. Administer a public rebuke. This will make the "hoggers" antagonistic or induce them to refrain from talking altogether. These people can create more confusion accidentally than you can intentionally. They are key people on your road to ruin. Encourage them.

13. Encourage Useless Debate. Guarantees to result in a "yes, it is" and "no, it isn't" discussion that uses up all the conference time and, more important, leads nowhere. Whatever you do, try to encourage the discussion so that the participants become highly emotional. The best planned company meeting can be broken up and ruined because everyone else learns only the prejudices and dogmatic ideas of the combatants.

14. Don't Draw Out the Reticent Member. If you do draw him out you may find that he has a great many fine ideas and can express them well. But this is apt to lead the meeting into productive channels. Soon the participants will be full of useful ideas for solving problems, making new products, etc. You will *never* ruin a conference in this manner. So watch your step.

15. Have Phone Calls of Members Transferred to the Conference Room. Best way known to ruin a meeting. Keeps party called from participating and interrupts the thoughts of everyone else. Personal calls from the conference leader's wife, or children, to pick up groceries show just how determined *he* is to ruin the meeting. Other members will develop an outstanding dislike for future conferences.

16. Answer All Questions Directed at You. Inject personal opinion heavily in discussions and answer all questions immediately. Referring the question to the group or redirecting the question to the questioner will only result in the group, collectively and as individuals, doing their own thinking. And don't label your opinions as such. State them as accurate facts. There is no need for a spirit of impartiality to prevail. If a group member wants to debate with you on a controversial point, do so. You can turn a meeting into a lively, stimulating cat and dog fight.

Continued on Page 382

customer reports prove

Big Savings with . . .

OCECO V-130 Conservation Regulators

Exclusive construction assures tight leak-proof closure fully up to operating setting — quick opening — and extremely high flows even at low pressures.

Oceco V-130 Conservation Regulators provide **greater flow capacity,** size for size, and pressure for pressure, **specially at low pressures** than **ever available before.** Our exclusive construction prevents vapors from escaping at less than set operating pressures. Positive flexing action of the membrane, held under tension, peels off and breaks away any icy formations, preventing freeze-ups. These valves bring never before secured **all weather** economy and dependability to the conservation of volatile products stored in cone, round, flat, lifter or expansion roof tanks. **Write for Bulletin No. 522. It gives full details!**

PRESSURE BALANCED CONSTRUCTION.

Tank pressures exerted on both sides of the pliable heat and cold resistant membrane keep membrane always under tension; —assuring tight seating fully up to operating setting— and positive flexing action that peels away icy formations preventing freeze-ups.

EXCLUSIVE OCECO FEATURE SAVES YOUR VAPOR DOLLARS!

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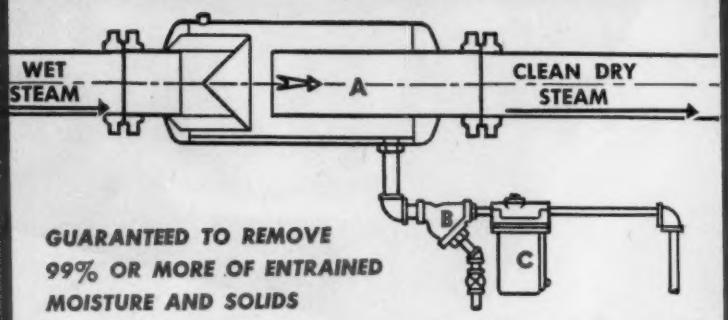
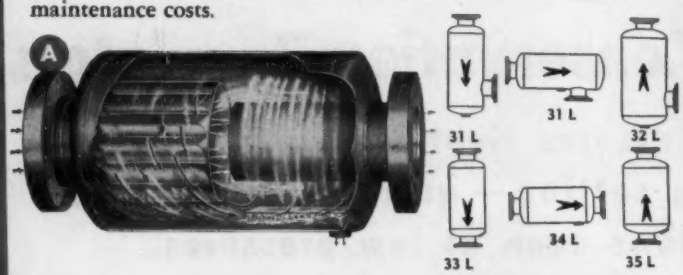
NOW—

The driest, cleanest steam available, is yours with this Wright-Austin equipment

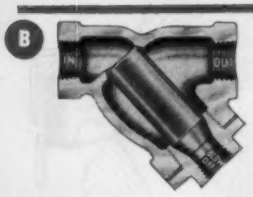


GUARANTEED TO REMOVE 99% OR MORE OF ENTRAINED MOISTURE AND SOLIDS

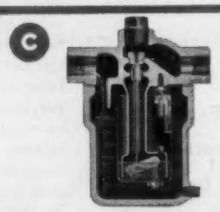
Live steam containing condensate, boiler compound, scale and other foreign matter is detrimental to equipment and is costly to super heat. These Wright-Austin accessories are engineered to give you maximum purification, resulting in lower fuel and maintenance costs.



This Wright Austin separator employs centrifugal force to remove impurities from steam, air or gas flow. The Type 30L, as well as other Models shown, are light weight, compact and sturdily constructed according to the ASME Code.



Foreign matter drains to Wright-Austin "Y" Type strainer which catches solids. These are periodically blown out by opening drain valve.



Condensate flows through strainer to Wright-Austin "Airxpel" Bucket trap. This unit automatically drains condensate as collected.

WRITE FOR NEW CIRCULAR

WRIGHT-AUSTIN COMPANY

3245 WIGHT STREET • DETROIT 7, MICH.

17. Be Blunt With Trouble Makers. To get a grouchy and negative member in a terrible mood, just tell him he's wrong when he blurts out his half-baked ideas. He will then become highly emotional and stubbornly defend all his remarks. A splendid feeling of resentment toward the leader develops. Don't let this trick you into using tact. Tactfulness is the prime requisite for a *successful* meeting. Let's have none of *that!*

18. Use No Humor. A good laugh aids a meeting. An amusing story interferes with heated arguments. A laugh tends to break down tension and relaxes the group. Easy discussion is encouraged. Great care must be used here or, before you know it, your conference is a success.

19. Ask Questions That Can Be Answered Only With "Yes" Or "No." This does not permit time consuming detailed answers. It will scotch all opportunity for participants to discuss the topic further by question, amplification, or disagreement. If you can't possibly ask the question in such a way as to elicit a "yes" or "no," then by all means use the leading question. This will put an end to bothersome thinking. The conference will develop into a "yes" and "no" social gathering, or into a debating society between the leader and his allies and the remaining participants.

20. Don't Use Charts or Blackboard. Charts tend to direct thinking. Besides, things that we see make a lasting impression on our minds. The participants are apt to remember

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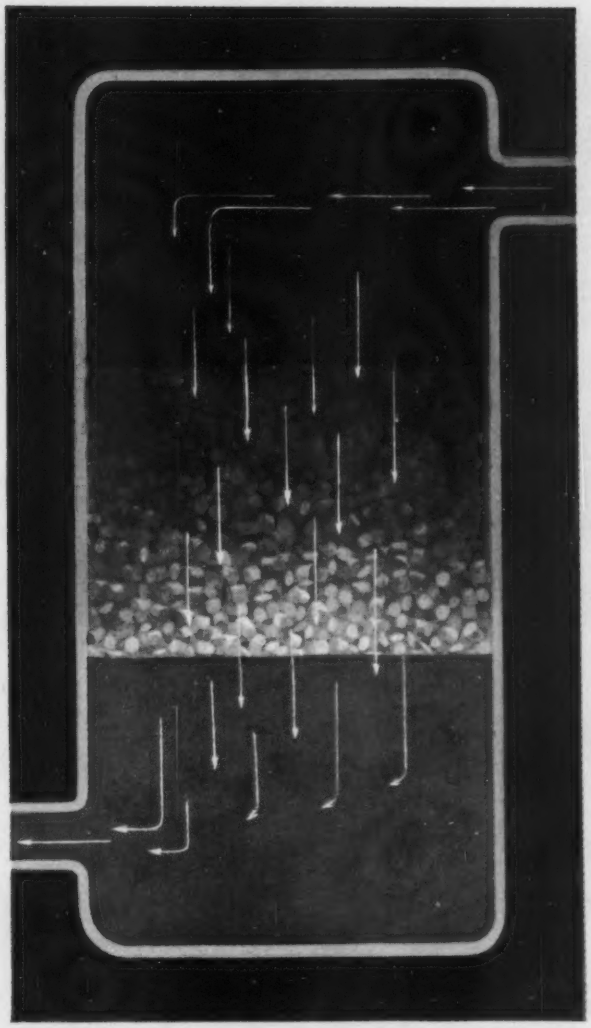

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New Cyanamid AERO HDS-2 extruded catalyst squarely meets modern hydrogen desulfurization requirements, featuring highest activity with low bulk density. Extensive laboratory and field performance data shows greater sulfur and nitrogen removal efficiency than other cobalt-molybdena types. Add the fact that the low bulk density of AERO HDS-2 gives up to 40% greater naphtha-treating capacity per pound of catalyst and you can see why it's the best buy for *your* hydrodesulfurization process.

Considerable performance data with reformer feed naphthas is already available on this outstanding product from another brand-new Cyanamid catalyst plant. This information will be glady supplied by your Cyanamid man. Write or phone him today.

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For normal or HDS-upgraded feedstocks, AEROFORM® Platinum Reforming Catalysts provide excellent performance in octane improvement. Good stability and easy regeneration contribute to their low cost-per-barrel.

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Where *extra* protection is required for engine break-in, AEROLUBE® 93-C concentrated zinc dithiophosphate does the job. Excellent oxidation inhibition and anti-wear properties make it ideal for both initial fill and regular use in premium oils.

The invaluable experience and advice of operating oil men is sought by Cyanamid's field men — is fed into our thoroughly modern laboratories — and results in superior, highly effective Cyanamid products. That is why each is so well suited for its recommended application.

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This is another "on-the-job" example of Washington Aluminum Company's creative engineering and precision fabrication. Washington Aluminum Company is America's largest company fabricating aluminum exclusively. Such specialization means finer methods of fabricating and welding, lower costs . . . more rapid delivery.

Specific advantages of Washington Aluminum Company's non-corrosive, high-strength walkways include: an exclusive, patented surface pattern that reduces slipping in the presence of oil, water or grease. Walkway openings to facilitate air circulation, eliminate fume and odor pockets. Painting and other maintenance are not necessary.

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vital points. Arranging ideas logically on a chart might stimulate the conferees to greater thinking. The horrible result? A lessening of the chance of forming wrong conclusions and forgetting important facts. In addition, the conferee will develop a sense of importance by seeing his contributions appear before the group.

21. Don't Become Familiar With Prepared Charts. Be surprised! Don't take undue advantage of the group by studying the charts beforehand. Just assume that everyone, including yourself, should understand each chart no matter how complicated it might appear. Just figure out what to say as you go along. To

add to the confusion and ruin, keep these techniques in mind: (a) Let shadows or glare engulf the chart, (b) use any old scribble in preparing the words, (c) put a half-day's information on one chart, (d) stand in front of the charts when you use them, and (e) use long and unnecessary words.

22. Don't Use other Visual Aids. Such aids as movies, film-strips, flip charts, etc., will increase interest as much as 40 percent, make a subject 25 percent more understandable, reduce learning time by 25 percent and add to the amount of learning that will be remembered for a year approximately 36 percent. It is well known that people like these visual aids. No use pampering them. If you *have* to use a film get one that does not present ideas or principles for consideration. On the contrary, get one that is designed on the "here's how to do it" or "we know it all" basis. To keep the leadership work off your back, never use the film as an aid. Let it do the

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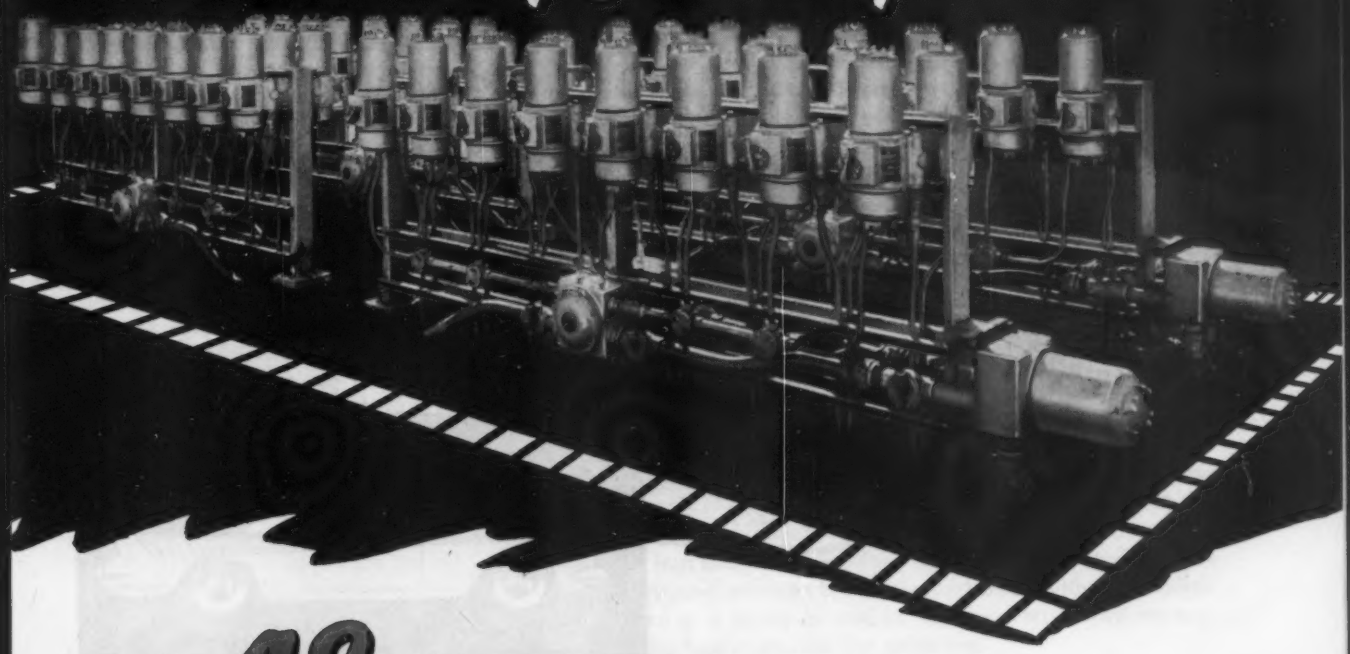
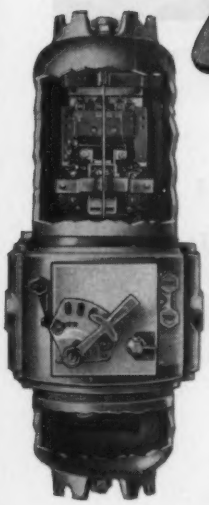
CROUSE-HINDS
Condulet* motor controls
Occupy Less Space!





48 Explosion-Proof Combination Motor Starters and Circuit Breakers . . . *in a 25 ft. x 6 ft. Area!*

Crouse-Hinds Condulet* Type EPC Motor Starters and Circuit Breakers are explosion-proof, dust-tight (dust-ignition-proof) and weather-resistant (raintight).

Lightweight cast aluminum construction for easy installation without use of lifting equipment.

Seven Conduit entrances simplify installation.

Built-in push button stations and selector switches are available.

Starter sizes 0 to 5. Circuit breakers 50 to 600-amp. frame sizes.

In the installation shown above, 48 Crouse-Hinds Condulet* Type EPC combination motor starters and circuit breakers are compactly arranged in four racks.

If necessary, the 25 ft. x 6 ft. area used could have been cut in half by installing the Condulet motor controls in two tiers. Or, *twice* as many Condulet controls could have been installed in the same area, if required.

The *vertical design* of Crouse-Hinds motor starters, circuit breakers and combinations allows them to be installed only ¼" apart. This compactness produces savings in the construction of steel mounting racks, and in the use of premium floor space.

● **For help in solving a space problem, see your Crouse-Hinds distributor . . . or call the nearest Office listed below**

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Ba additives

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Westvaco is keeping well ahead of the rapidly rising demand and will continue in the years ahead to fulfill its responsibilities as the leading supplier of barium chemicals. By increasing our productive capacity and mineral reserves, and by research to develop useful new forms of barium, we constantly anticipate the needs of all users.

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entire teaching job. While the lights are out you can get in 40 winks.

23. Never Use Case Material. Meetings are queered from the start by using only theoretical discussions. Good, practical case studies might induce thinking, analysis, pro and con discussion, and genuine efforts to find a solution among a typical group of participants. If you do break down and use a case, use actual cases. Let everyone know the personalities involved. This will make individuals in the group or known to the group feel "framed" or "put on the spot."

24. Don't Summarize Main Points Before Closing. Increases chances of conference falling flat. If any good topics were discussed the participants won't remember them, can't apply any good suggestions. A good summary is apt to leave the participants with a feeling of accomplishment. An acknowledgment or review of the minority viewpoint, highlighting its merits, but indicating why it was rejected, will remove the minority members' feelings that there is a stigma attached to having been on the wrong side. But don't be tempted to do this. No summary will help kill the present meeting and stultify subsequent conferences.

25. Don't Close Meeting On Time. This is the clincher. Now everyone is mad. Rides and buses have been missed. It is too late for participants to call home and prepare the little wife. Dislike for meetings is built up. You, the leader, are a complete success. You have successfully ruined a company meeting. ##

Is It Sound Economy to Invest in a KINNEY PUMP ?

For an ordinary pumping function, the answer is an emphatic – NO!

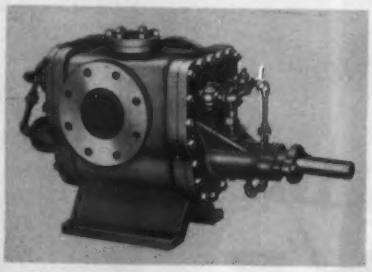
BUT • • •

If you must move highly viscous materials (tars, waxes, asphalt, gas oil, bunker, etc.), liquids containing non-abrasive solids, or a broad range of liquids (asphalt, molasses, brine, gasoline, alcohol, etc.), regardless of first cost, you'll be well advised to know the abilities of–

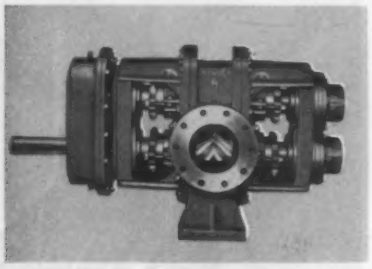
Kinney®

ROTARY PISTON and HELIQUAD PUMPS

KINNEY Pumps are designed and built to "pump the unpumpables." They are not conventional liquid handling pumps adapted to handle difficult materials. Their original concept called for doing a superlative pumping job on tars, asphalt and blackstrap molasses. That they will also pump gasoline or water is purely coincidental. It is this basic engineering–to answer the needs of special functions–that reflects amazing economies in operation and maintenance. Many KINNEY Pumps have worked at these rugged services ten years and more without a single breakdown or a penny in cost for repairs! That's why we say, "look at the true costs–not the price tag."



KINNEY Rotary Piston Pumps – Plain or Steam-Jacketed models – capacities 2 to 600 gpm. High suction lift. Pressures 25 to 250 psi. Frequently used to meter flow.



KINNEY Heliquad Pumps. Plain or Steam-Jacketed models – capacities 10 to 2000 gpm. Selection of rotors to suit material pumped. High Vacuum characteristics – non-pulsating flow. Pressures 10 to 250 psi.

WRITE: Get the full story on KINNEY Liquid Handling Pumps.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3596J WASHINGTON STREET • BOSTON 30 • MASS.

Please send me full particulars on KINNEY Rotary Piston and Heliquad Pumps.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

PROCESSING EQUIPMENT for the PETROLEUM,

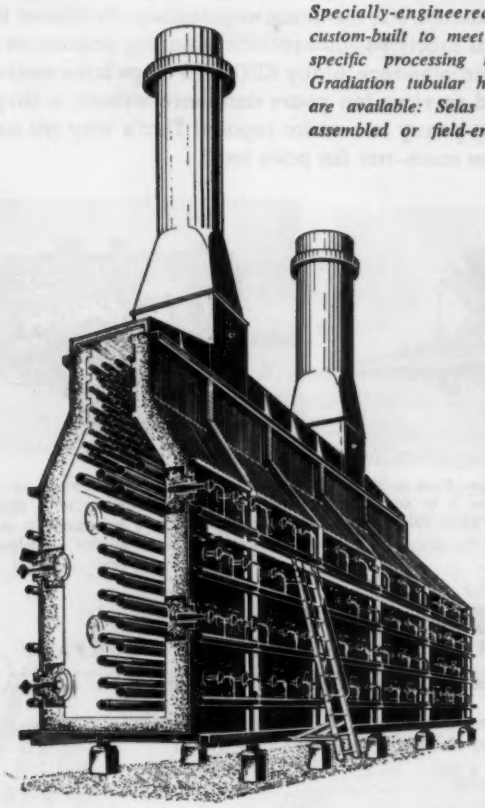
IN CRITICAL PROCESSING OPERATIONS WHICH REQUIRE:

- Preciseness in heating
- Ability to handle a variety of feed stocks, *ethane and butane in one heater, for example*
- Instant response to controller demand *achieving closer equilibrium approach*
- Zone Control—*up to 3 independent coils in the same heater*

SELAS GRADIATION® HEATERS are specified.

These heaters have proven highly beneficial in numerous critical applications, including:

- Visbreaking
- Light Hydrocarbon Pyrolysis
- Catalytic Reforming
- High Temperature Heating *including cylindrical vertical reactors*



Specially-engineered and custom-built to meet your specific processing needs, Gradiation tubular heaters are available: Selas shop-assembled or field-erected.

NOW

SELAS ANNOUNCES ECONOTHERM*

a new family of TUBULAR HEATERS

For many good reasons, chief of which is the demand for heaters to accomplish non-critical processing, Selas Corporation of America has created a new family of tubular heaters to be known as Selas Econotherm Tubular Heaters.

Econotherm Heaters are being used where operations require materials to be heated to below decomposition temperatures; where, because of this condition, precise control is not essential; where, because of the nature of the operation, low cost is an important factor.

Actually, Econotherm Heaters are not new to Selas or to its customers. Previously furnished as custom-built units to meet specific non-critical requirements, basic Econotherm designs have now been developed to achieve maximum economy. Three representative configurations, together with their processing capacities, are shown on the facing page.

And, to meet processing conditions not covered by these standard units, specially-designed Econotherm Heaters will continue to be custom-built as required.

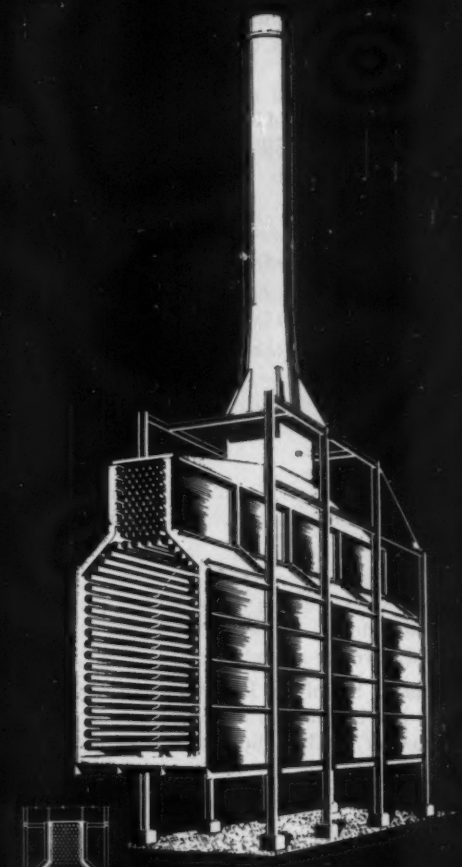
Unlike Selas Gradiation Heaters which use Duradiant burners to accomplish their preciseness of heating in critical processing, Econotherm Heaters employ flame-type burners and can accommodate gas, oil or combination firing.

The addition of this new family to Selas' Fluid Processing Division serving the petroleum, petrochemical and chemical industries, rounds out the line of heaters so that processors may call upon Selas for every heat-processing need.

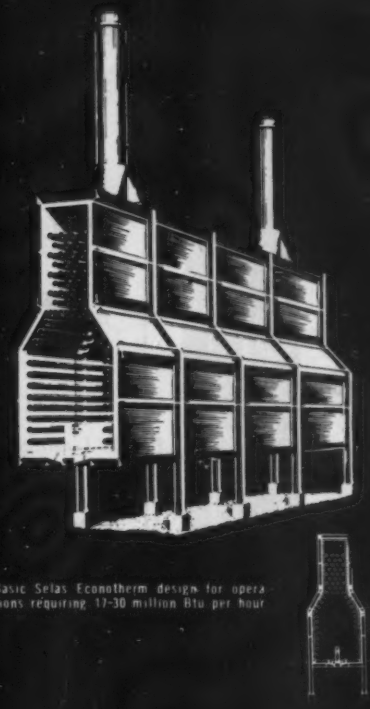
SELAS
CORPORATION OF AMERICA
DRESHER, PENNSYLVANIA

Trade Name

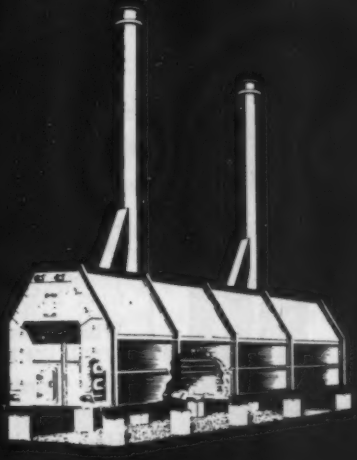
PETROCHEMICAL and CHEMICAL INDUSTRIES



Basic Selas Econotherm design for processes requiring more than 30 million Btu per hour



Basic Selas Econotherm design for operations requiring 17-30 million Btu per hour



Basic Selas Econotherm design for processing requirements from 8-17 million Btu per hour. A basic design is also available for requirements up to 8 million Btu

Write Dept. 149 for bulletin "Gradiation Heating for Petroleum and Chemical Processing" and for more detailed information about Selas Econotherm Heaters.

Heat and Fluid Processing Engineers

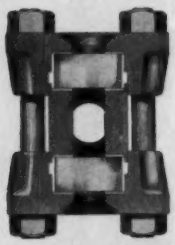
DEVELOPMENT · DESIGN · CONSTRUCTION

SELAS

Strahman

HIGH PRESSURE GAUGES

USED IN REFINERIES AND CHEMICAL PLANTS THROUGHOUT THE WORLD



THRU VISION

REFLEX
Single or Multiple Sections

TUBULAR

Gauge Cocks
•
Large Chamber Reflex Gauges
•
Heated or Cooled Gauges

SEND FOR COMPLETE CATALOGUE

STRAHMAN VALVES, Inc.
16 Hudson St., New York 13, U.S.A.

If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

"If Oil Could Speak" it would tell the American public:

Is Gasoline Really a Bargain?

Coffee and soft drinks cost $1.60 per gallon, gasoline an average of less than 31 cents. And that price includes almost 8 cents in state and federal taxes.

Is the Oil Industry Fair to Its Employes?

In addition to paying the highest wages in the nation, last year fringe benefits paid out by the oil industry averaged $1278 per employe. This compares with $819 per employe for all industries.

How Much of Our Chemical Supply is Derived from Petroleum?

Of the record-breaking 127 billion pounds of chemicals produced in the U. S. last year, one quarter, or 35 billion pounds were derived from petroleum.

What Does It Cost to Improve Gasoline Quality?

It costs oil companies half a billion dollars to improve the quality of gasoline by one octane number. Yet the average octane number of gasoline has risen from 74 to nearly 100 in the past 27 years.

What Does It Cost to Build Oil Reserves?

In 1956 oil men spent a record three billion dollars searching for and developing 1.2 billion barrels of crude oil reserves. Authorities have estimated that the nation's oil men must discover at least 70 billion barrels of new oil in the next 20 years. This is as much oil as they found from 1859 to 1950.

What Does Oil Do For Me?

The oil industry has created an estimated 60,000 jobs in the city of New Orleans alone. A prime example of the oil industry's contribution to the nation's economic growth.

How Much Gasoline Does the U. S. Consume?

Every minute about 105,000 gallons of gasoline are used in the nation's vehicles, boats and industrial engines—or, 55,188,000,000 gallons per year!

How Do Oil Employes' Wages Compare With Industry As a Whole?

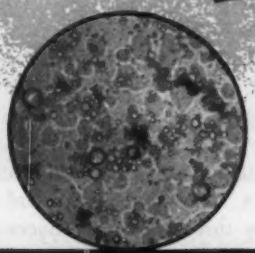
Quoting the Bureau of Labor Statistics, refinery workers' wages increased 60 percent from 1947 to 1955. Whereas the average hourly wage for all manufacturing employes in 1955 was $1.88, the average hourly wage of refining employes was $2.46. U. S. Chamber of Commerce reports the oil industry pays the highest yearly salary—$5259. After petroleum, the four highest average salaries listed are machinery, printing and publishing, transportation equipment and primary materials.

Visco Laboratory Reports

TAKE THE RISK OUT OF DESALTING TREATMENTS

No one knows better than you the dollar loss from a poor desalting set-up.

And you know, too, there's no such thing as a blanket cure-all. But a Visco Laboratory Report *does* point the way to the results you want—from every type of crude—at no added cost to you.



Photomicrograph—
Emulsified refinery crude

In a typical case, 20 or more separate desalting compounds and laboratory formulas may be checked and all contributing factors will be considered before the final desalting recommendation is made.

Photomicrograph—Emulsified refinery crude after Visco desalting

If you would like our desalting recommendation for your crude, send Visco a five-gallon can of the crude and one gallon of the water used in your refinery desalting. Or better yet, check with your Visco representative, and he will arrange for these services.

VISCO PRODUCTS COMPANY
INCORPORATED
1020 Holcombe Blvd. • Houston 25, Texas • Telephone JAckson 8-2495

Visco® CONSISTENTLY EFFICIENT OIL INDUSTRY CHEMICALS

What's Happening . . .

. . . in the Industry

Varied Company Reactions Greet Voluntary Import Plan

Ten oil importers have telegraphed government that they will comply fully with the administrations' new voluntary import program, while ten companies have asked for either formal or informal hearings to adjust quotas.

Sun Oil has informed the Interior Department that it "cannot agree to join other units" in the voluntary program because of possible conflict with antitrust laws.

Companies, which promised full compliance to program director Capt. M. V. Carson, USN, are: Gulf, Texaco, Gabriel Oil, Shell, Esso Standard, Socony Mobil, Lakehead Pipe Line, Phillips, Cities Service and Southwestern Oil & Refining. Phillips added that discovery of new reserves in the future would be grounds for it to seek a higher quota.

Highlights from telegrams of other importers include:

Standard of Ohio: desire to cooperate, but requests formal hearing to obtain higher quotas.

Northwestern Refining: will cooperate, but wishes informal meeting with Carson to correct "discrepancies" in import figures, on which company's quota was based.

Standard of California: will cooperate, but ask imports level of 67,000 bpd for districts 1-4 (formula calls for 66,800 bpd).

Indiana Standard: seeks informal meeting to discuss operation of program; also wishes to review "discriminatory" quota given company.

Eastern States Petroleum: wants to correct "error" in import estimates on which company's quota was based.

Lake Superior Refining: seeks higher adjustment in quota, although will cooperate with program.

International Refineries, Inc.: seeks informal meeting with Carson to correct "error" in company's estimate, on which quota was based.

Sinclair: seeks formal hearing to revise quota, although company pledges cooperation with program.

Great Northern Oil: pledges cooperation, but wants to discuss program informally with Carson.

Tidewater: seeks formal hearing to adjust "highly discriminatory" quota given company.

Pure Oil Sues Strikers

The Pure Oil Co. has filed suit for $963,621 in a U. S. District Court in Chicago against the Oil, Chemical & Atomic Workers which are engaged in a strike at the company's Lemont, Ill., refinery.

The suit charges that the Local's picketers prevented employes of two contractors, The M. W. Kellogg Co., and Tellepsen Petro-Chemical Contractors, Inc., from working on construction at the plant from June 4 to July 1, and induced work stoppage of the contractors' men on August 12.

Pure also alleges that picketing forced contractors about July 1, to employ OCAW strikers on the construction project. It asserts that resultant construction delays damaged the company to the extent of $963,621.

Small Refiners Uneasy As Military Cuts Petroleum Needs

Early last month it was rumored that the Military Petroleum Supply Agency would announce a 25 percent cutback in its anticipated petroleum product purchasing for the fiscal year 1958. It was thought that the sharp reduction would be the result of pressures for economy being exerted throughout the Defense Department on the heels of President Eisenhower's order to government agencies to cut spending.

A week later the Agency was still mum on the details of the cutback, but Rear Adm. O. P. Lattu, director of the Agency said the "cutback would affect all products, but would be particularly heavy in Navy special fuel oil and aviation fuel." He estimated that MPSA would have to slash purchases by ten to fifteen percent during the fiscal year 1958. This means a cut of from $115 million to $170 million.

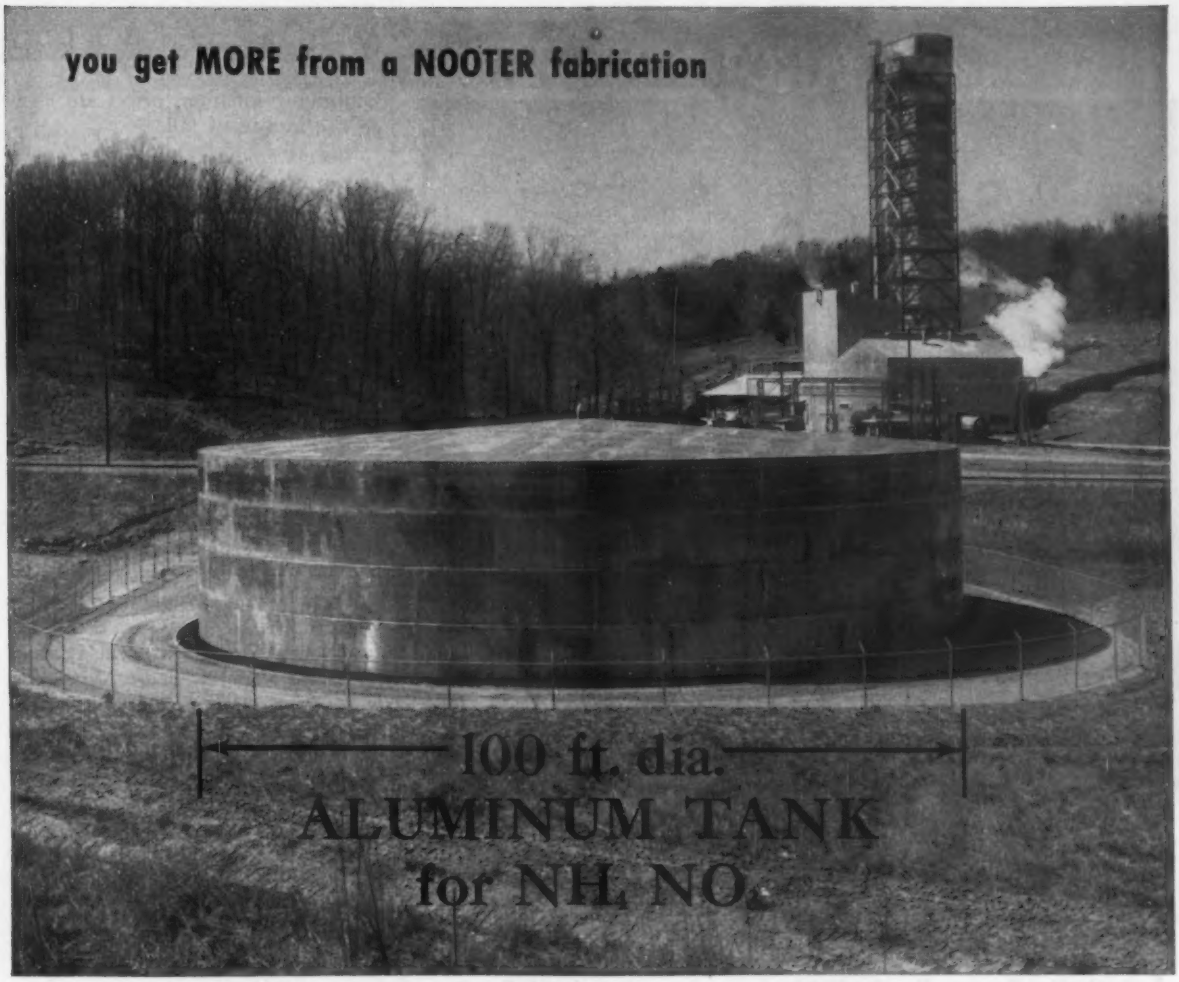
Lattu added that, "specific effects will not be known until the services have had an opportunity to review their operational plans and rework programs reflecting the import of the order. The over-all result of the order, however, may mean not only reduced procurement requirements by the military services, but also a reduction in liftings against contracts currently in effect."

Possible Exceptions. Five days after Lattu made these statements, it was made known that there might be possible exceptions made for specific petroleum products in the Pentagon's "across the board" purchasing cutback order. A high Defense official said that the three military services may be allowed to maintain their present purchases levels for specific products if they can justify requirements.

At the same time, Senator O'Mahoney (D-Wyo.) lashed out at the Defense cutback as a "very real danger" to military training and a serious economic hardship on small refiners.

The Wyoming lawmaker said that the defense of the nation "is being subordinated to a fiscal policy." The cut poses a real danger to effective training of military personnel," he said, since the services will have to curtail the use of necessary petroleum products in operation of equipment needing liquid fuel. This is "false economy" he added, and will not save the government in the long run.

"It is doubtful whether any real economy will be effected because with



Here's another big Nooter job, an aluminum tank for storing 83% ammonium nitrate solution. It was built for Mississippi River Chemical Company. This squat, but mighty reservoir has a height of 23 feet, a girth of over 314 feet. Walls and interior structure are aluminum, which was specified for its corrosion resistance to this fertilizer raw material. And Nooter fabricating experience assured flaw-free welds throughout.

But any other material, or any other storage tank design would have been field erected just as perfectly, finally inspected just as carefully and completed on time.

For your next big job, talk to Nooter. You'll find Nooter's quality and dependable schedules your best equipment investment.

Write for
PLANT SURVEY REPORT NO. 4
for a comprehensive report
on Nooter facilities

NOOTER CORPORATION

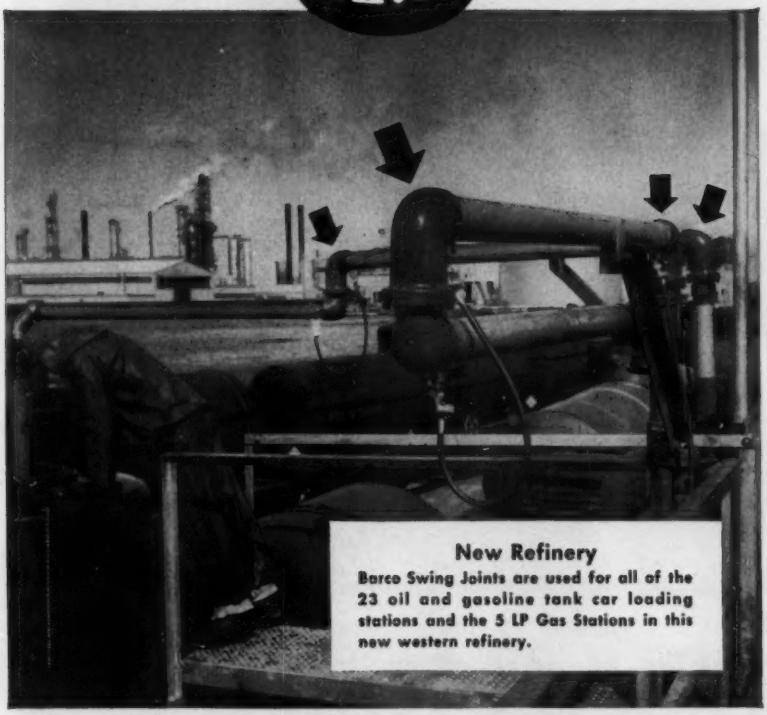
"Since 1896"

Steel and Alloy Plate Fabricators and Erectors..."Boilermakers"

1404 SO. SECOND ST. • ST. LOUIS 4, MO.

For more data on advertised products, use Readers' Service Cards, last page.

SWING JOINTS BARCO ASSEMBLIES

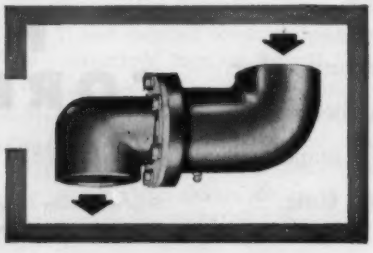


New Refinery
Barco Swing Joints are used for all of the 23 oil and gasoline tank car loading stations and the 5 LP Gas Stations in this new western refinery.

How Barco Makes Refinery Loading Racks Work Better!

1. **Controlled Torque**—Here is a feature users unanimously applaud in Barco's new Swing Joints—*no annoying, uncontrolled free swinging of lines.* They swing easily but stay put.
2. **Ball Bearing and O-Ring Equipped**—Designed specifically for handling gasoline, oil, lube oil, LP gas, and other fluids, including many chemicals, *without leakage.*
3. **Large Bearing Surface**—Barco's bearing design provides adequate support for lengths of piping. Minimizes bearing pressures and wear.
4. **Long Life**—New "Bar-Moly" dry lubricant process used by Barco gives a permanent anti-galling, corrosive-resistant finish to moving parts. This, combined with routine lubrication, insures longest possible maintenance-free service.
5. **Easy Maintenance**—Joints can be disassembled for inspection without disconnecting piping. O-rings are easily renewed in the field. Frequent greasing not required to maintain sealing.
6. **Custom Designed Installations**—Your Barco Representative will be glad to show you actual models of smooth-working, balanced assemblies and a wide choice of Barco custom designs. Choice of materials, including all-steel. Sizes 1″, 1½″, 2″, 2½″, 3″, 4″, 6″, and 10″—eleven different styles of joints. Ask for Catalog 400.

BARCO
Manufacturing Co.
542K NORTH HOUGH STREET
BARRINGTON, ILLINOIS
Worldwide Sales and Service



What's Happening. . .

continuing inflation, prices are likely to rise instead of fall.

"Replacement of these reserves at some future date will require expenditures of an even greater sum than those now saved by this so-called economy move."

Small Refiners Hurt. "Meanwhile, refiners—particularly small refiners—whose contracts are being cancelled with only a portion of their deliveries having reached the Defense Department, will be subjected to serious economic hardship." He added that refiners' output has been set to meet specifications of military. Specialized fuels, for example will have no commercial market.

Then before PETROLEUM REFINER went to press, another voice was heard from when Elmer E. Bratzell, Counsel for Independent Refiners Association of America, made public the contents of a letter he wrote to Charles E. Wilson, Secretary of Defense.

"I am writing you," Bratzell stated, "on behalf of the Independent Refiners Association of America to urge you to act to insure that the recently announced curtailment on military buying of petroleum is carried out in a planned and orderly manner." He said that there should be some regard for the effect of sudden and drastic changes in buying patterns upon refiners with whom the military has contracts. This is especially true of independent refiners because of their economic vulnerability and smaller operations.

Loophole Seen. Bratzell went on to say that the present curtailments "point up a serious loophole in the structure of military procurement. National policy with regard to competitive bidding, and the preference and set-asides for small business, are carried out in the letting of procurement contracts. But these national objectives can be completely undermined and ignored by the way in which contracts are actually carried out. If a small refiner gets a contract but receives very reduced orders for delivery under it, the contract has proved meaningless."

Bratzell also made known a letter to Senator O'Mahoney in which he

For more data on advertised products, use Readers' Service Cards, last page.

Do You Buy Desiccants?

Reynolds Activated Aluminas are low in cost, have high capacity, are inert to most chemicals

Reynolds Activated Aluminas have no written formula. They are mixtures of various forms of Al_2O_3 and H_2O. Their component water contents vary from 0% in aluminum oxide to 34.6% in trihydrated aluminum oxide.

In-between compounds are formed under carefully controlled conditions to generate crystalline arrangements with maximum surface area to take advantage of the direct relationship of high surface area to degree of adsorption. The following table indicates the high adsorptive capacity of activated aluminas.

Two grades of activated alumina are available at present. The two grades are identical chemically, but differ only slightly in their capacity to adsorb moisture.

TYPICAL CHEMICAL PROPERTIES OF GRADES R-2101 AND R-2102 ACTIVATED ALUMINA

(Analyses in Percent on Dry Basis)

Al_2O_3	Na_2O	SiO_2	Fe_2O_3	TiO_2	Combined H_2O
91.5	0.75	0.10	0.02	0.002	7.0

TYPICAL DYNAMIC ADSORPTIVE CAPACITY

(Capacity in Percent on Dry Basis)

Grade	At 10% Relative Humidity	At 20% Relative Humidity	At 40% Relative Humidity	At 60% Relative Humidity	At 80% Relative Humidity
R-2101	3.6	5.1	7.6	12.0	16.0
R-2102	3.3	4.8	7.0	11.0	15.0

SPECIFICATIONS FOR SHIPMENT

(Analyses in Percent on Dry Basis)

Grade	Al_2O_3 (Min.)	Na_2O (Max.)	SiO_2 (Max.)	Fe_2O_3 (Max.)	TiO_2 (Max.)	Combined H_2O	At 10% Relative Humidity	80% Relative Humidity
R-2101	90	0.80	0.12	0.10	0.02	9.0	3.3	15.0
R-2102	90	0.80	0.12	0.10	0.02	9.0	3.0	13.0

PARTICLE SIZE

Activated Alumina is offered in the following three standard particle sizes:

(1) Thru ½" on ¼" (2) Thru ¼" on 8 mesh

(3) Thru 8 mesh on 14 mesh

The advantages of activated aluminas as a desiccant include their low initial cost, their high capacity (see table above), and the fact that they are inert compounds in the presence of most chemicals. They may be used in contact with other chemicals without affecting them or the function of the activated aluminas themselves.

A major economy in the use of activated aluminas as desiccants stem from easy reactivation. Heating for a few hours at 175 to 200° C accomplishes complete reactivation. Activated aluminas in commercial use are usually placed in twin units with built-in heating elements. Thus one unit is in service while the second is being reactivated. In such a system plant operation can be continuous.

The wide variety of activated aluminas applications can best be described with a listing of its uses:

- *they dry gases:* air, nitrogen, hydrogen, oxygen, carbon dioxide, chlorine (some reaction), sulphur dioxide (slight decomposition of alumina), freon, ethylene, butane, by-product coke gas and natural gas.
- *they dry liquids:* pyridine, ethyl acetate, gasoline, coal tar derivatives, benzol, toluol, methyl alcohol, vegetable and animal oils, melted waxes, carbon tetrachloride.
- *they are used* to keep air lines free of water, to keep oil and gas lines dry.
- *they provide* dry air for transformer breather systems.
- *they have an affinity* for fluorine, highly effective in water defluoridization, and in HF alkylation.
- *they are effective* filtering media for turbine oils.
- *they are used* as catalyst carriers in petroleum refining.

Government Specifications: R-2101 Activated Alumina meets the rigorous requirements of joint Army-Navy Specification 169-D, later superseded by the military specification MIL-D-3716. Adsorptive capacity defined for Reynolds Activated Alumina is determined in accordance with methods prescribed by the above mentioned specification.

Shipping: Reynolds Activated Aluminas are offered in 100 pound lined burlap bags, in foil lined bags, in 400 pound steel drums, and in fiber drums. Minimum shipping quantity is 100 pounds. They are available in various particle size ranges.

Complete research and engineering services are available from Reynolds Metals Company to assist you in solving chemical, material or shipping problems. Samples and data sheets are available on Alumina Hydrates, Calcined Aluminas, Aluminum Dross and Aluminum Powders. Consult the Reynolds Office nearest you, or write direct to *Reynolds Metals Company, P.O. Box 1800-CT, Louisville 1, Ky.*

The Finest Products Made with Aluminas are made with REYNOLDS ALUMINAS

See "CIRCUS BOY," Sundays, NBC-TV.
Watch for Reynolds on "DISNEYLAND," ABC-TV.

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

told the Senator, "the questions you have raised and the position you have taken are wholeheartedly supported by this association and its member refiners.

API O. K.'s Lube Name

Approval of a new designation, "Multipurpose-Type Gear Lubricant (A.P.I. Service GL4)," to define the new higher performance multipurpose gear lubricants now being placed on the market has been announced by the American Petroleum Institute.

The designation has been approved by the Division's Lubrication and General Committees, and has been reported to the Society of Automotive Engineers. It was designed to meet the automotive industry's requirement for a designation and definition significantly different from current ones, to assure that the new lubricants would be furnished when called for in car owners' instruction manuals.

The definition to accompany the new designation is as follows:

"This term designates lubricants which have adequate load carrying ability and other required properties to protect hypoid gears in sustained high speed and/or high torque service in modern high powered passenger cars and trucks. These lubricants are also suitable for use in spiral bevel gears, many transmissions, and worm gears in some types of service. Such lubricants are identified as meeting 'A.P.I. Service GL4.'"

Shell Develops Lubricant For 'Free Piston' Engines

The first and only high load-carrying lubricant designed expressly for trouble-free cylinder lubrication of free piston gas generators has been introduced by the Shell Oil Co., New York, under the name "Free Piston Engine Oil." More than six years of research and field testing went into the development of the oil, which is reported to minimize ring and cylinder liner scuffing and scoring, rapid ring wear, deposit formation in engine case and upon compressor delivery valves.

Shell states that the new oil is being made available to meet the lubrication requirements of free piston gas engines produced in Europe and in the United States for electric utility, marine and locomotive use. This type of engine is also being considered by three automobile producers in the U. S. and one in France for possible automotive use. Since these engines attain the high thermal efficiency of the diesel cycle with the simplicity of turbine shaft output, the result is an increase in overall economies and a decrease of maintenance costs. Hitherto, the lack of a suitable cylinder lubricant caused excessive engine wear.

In the development of this new oil, Shell has worked with the pioneers of the free piston engine industry, Societe Industrielle Generale de Mecanique Appliquee (SIGMA), Lyon, France. The oil is presently in use in practically all the gas generators built by this company and their licensees in this country, with the exception of those operated by the French Navy. According to SIGMA, "Shell has given the most attention to finding a suitable oil for the lubrication of GS 34 generators and was the first to develop an oil which satisfied the lubrication requirements of these units in continuous service."

Because of the comparatively low temperature of gases from the free piston engine, there is no need for special alloy materials for turbine blading. It was the combination of the high compression prespressures and piston temperatures which originally gave rise to lubrication problems.

South Texas AIChE to Meet

Nearly a thousand engineers are expected to attend the twelfth annual technical meeting in Galveston, Texas, October 18, an event sponsored by the South Texas section of the American Institute of Chemical Engineers.

Chemical engineers from all parts of the Southwest will assemble at the new Moody Convention Center to hear local and national authorities speak on such topics as:

Miscible Displacement Processes in Capillaries, R. J. Blackwell and D. V. von Rosenberg; Orifice Mixing—Surface Formation In Immiscible Liquids, L. S. Scott and C. D. Holland; Calculation of Static and Flowing Bottom Hole Pressures of Natural Gas Wells From Surface Pressure Measurements, Paul Crawford; Mass Transfer Between a Gas Bubble and a Liquid, D. E. Wade, G. T. McBride, and W. W. Akers; The Pall Ring—A New

Oil refineries

in many countries successfully equipped their modern plants with B&R Gate Valves, Globe Valves, Swing Check Valves, Safety Valves. B&R Valves are manufactured according to API specifications. Flange dimensions conform to ASA. Materials correspond to ASTM. One trial with our Valves will make you our customer for ever. Please ask for B&R catalog We 110e with detailed particulars on our lines of **oilfield and refinery equipment.**

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LOOK! A Dozen Refinery Problems... Bucyrus-Erie Hydrocranes Solve Them All

PROBLEM	HYDROCRANE'S SOLUTION
1. Travel time between jobs	Up to 50-mph travel speeds
2. Fragile loads	Precision hydraulic control
3. Frequent setups	Hydraulic outriggers that set in seconds
4. Close quarters	Shortest tail swing in its class
5. High lifts	Boom lengths to 72 feet (Optional with jib)
6. Frequent boom angle changes	Working boom hoist
7. Deep hole clamshell digging	New selector valve greatly increases line speed
8. Excessive downtime	Simple design cuts costly maintenance
9. Heavy loads	5-ton H-3 or 10-ton H-5
10. Inexperienced operators	Clearly marked hand levers
11. Rough, irregular ground	Outriggers level machine hydraulically
12. Spot digging jobs	⅜- or ½-yd. hydraulic clamshell

Yes, Hydrocranes are the only crane-excavators that do so many refinery jobs so well. Mounted on a new or low-cost used truck, the 5-ton H-3 and 10-ton H-5 are digging and lifting units that return more per dollar invested than any other machines in their classes. Your Bucyrus-Erie Hydrocrane distributor will be happy to provide full information on either of these outstanding, all-hydraulic machines. 221H57

A Familiar Sign . . . BUCYRUS ERIE *. . at Scenes of Progress*

BUCYRUS-ERIE COMPANY SOUTH MILWAUKEE, WISCONSIN

What's Happening . . .

Type of Tower Packing, John Eckert, Chief Engineer.

Changing Maintenance Requirements in the Chemical Industry, O. S. York; Maintenance Planning and Execution, F. D. Macy; The Use of Models in Design and Construction, A. E. Michel; The Chemical Engineer's Contribution to Lower Construction Costs, R. C. Rohdanz.

Economics of Plant Locations With Respect to Natural Gas Supplies, Leonard R. Brooks; Electronic Aids to Chemical Engineering, R. W. Olson; Evaluation of Atmospheric Corrosion Rate With Area and Prevailing Wind Throughout an Industrial Plant Site, C. F. Schrieber; Phase Equilibria at High Pressures, D. L. Katz.

Radiation Hazards to Mankind, Vincent Collins, M. D.; and Planning for Disasters, L. J. Grossheim.

Octanes Dip Slightly

Gasoline on sale at service stations in August showed national weighted averages of 98.1 octane number for premium and 90.9 octane number for regular, according to the latest monthly survey of antiknock quality compiled by Ethyl Corp.

The premium average was 0.1 octane number below the July average. The regular average was unchanged from its July level. Compared with a year ago, the premium average was 1.1 octane number higher and the regular average was 0.8 octane number higher.

Average tetraethyl lead contents in August were 2.62 ml per gallon of premium gasoline and 2.19 ml per gallon of regular gasoline.

Twenty-four of the 57 cities in Ethyl's survey reported increases over July in the average octane number of their premium gasoline. Twenty-two cities reported decreases and 11 cities remained unchanged. In regular gasoline, 19 cities reported increases over July in the average antiknock quality, six by 0.5 octane number or higher. Twenty-eight cities reported decreases while ten cities were unchanged.

Compared with the nationwide premium average of 98.1 octane number, two cities reported premium averages of 99 octane number or higher. In regular gasoline 18 cities showed average octane ratings of 91.5 octane number or higher, compared with the national weighted average of 90.9 octane number.

For companies marketing more than one grade of premium, the survey showed a range of 100.0 to 101.5 octane number for the highest grade, on the basis of 37 samples in 19 cities.

Gulf Ups Educational Aids

Gulf Oil Corporation has announced a new six-fold program which increases Gulf's financial and other aid to the nation's colleges and universities.

In making the announcement, Gulf's president, W. K. Whiteford, said Gulf would increase its budget for educational grants and broaden the scope of its contributions for aid to undergraduate schools, as well as continue its already existing graduate fellowships.

The new plan adds about $250,000 annually to the amount Gulf has been budgeting for aid in recent years. Some

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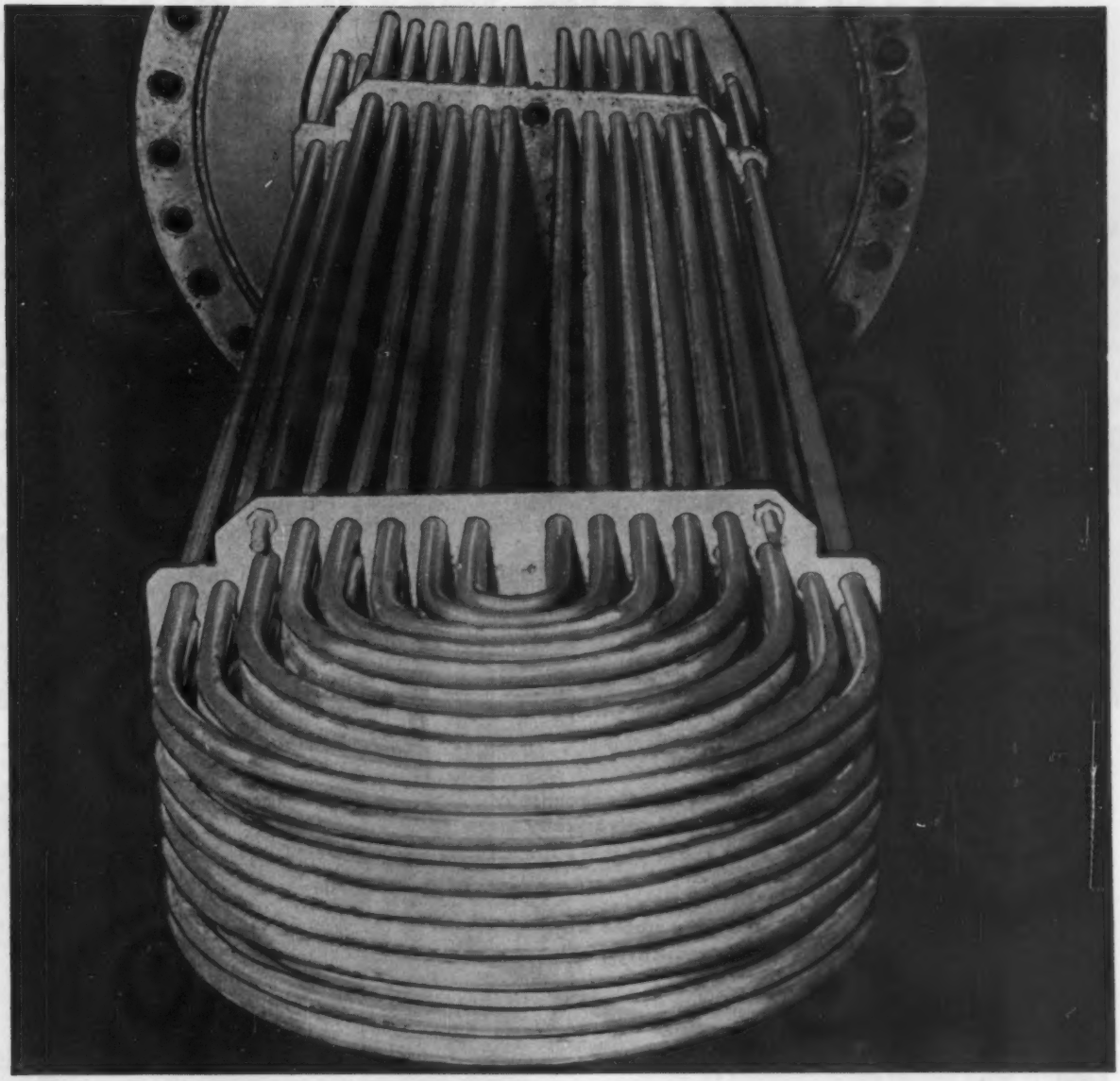

Carpenter Stainless No. 20Cb Tubing withstands Tortuous Fabrication and Service

Note the tortuous hairpin bends in this tube bundle used in a large oil refinery to handle concentrated H_2SO_4 at temperatures from 175-194°F, and pressures from 300-400 psi. Whenever and wherever *you* design or use equipment that handles severe corrodents, check the service-proved cost-saving results you can expect with Carpenter Stainless No. 20 and No. 20Cb. Ask your Carpenter Distributor about these super stainless alloys available in tubing, pipe, sheet, plate, bars, wire, strip and billets.

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The Carpenter Steel Company,
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Export Dept.: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Carpenter

more data corrosion resistance

Stainless Tubing & Pipe

Carpenter No. 20 bars, strip, wire and billets are available also from The Carpenter Steel Company, Reading, Pa.

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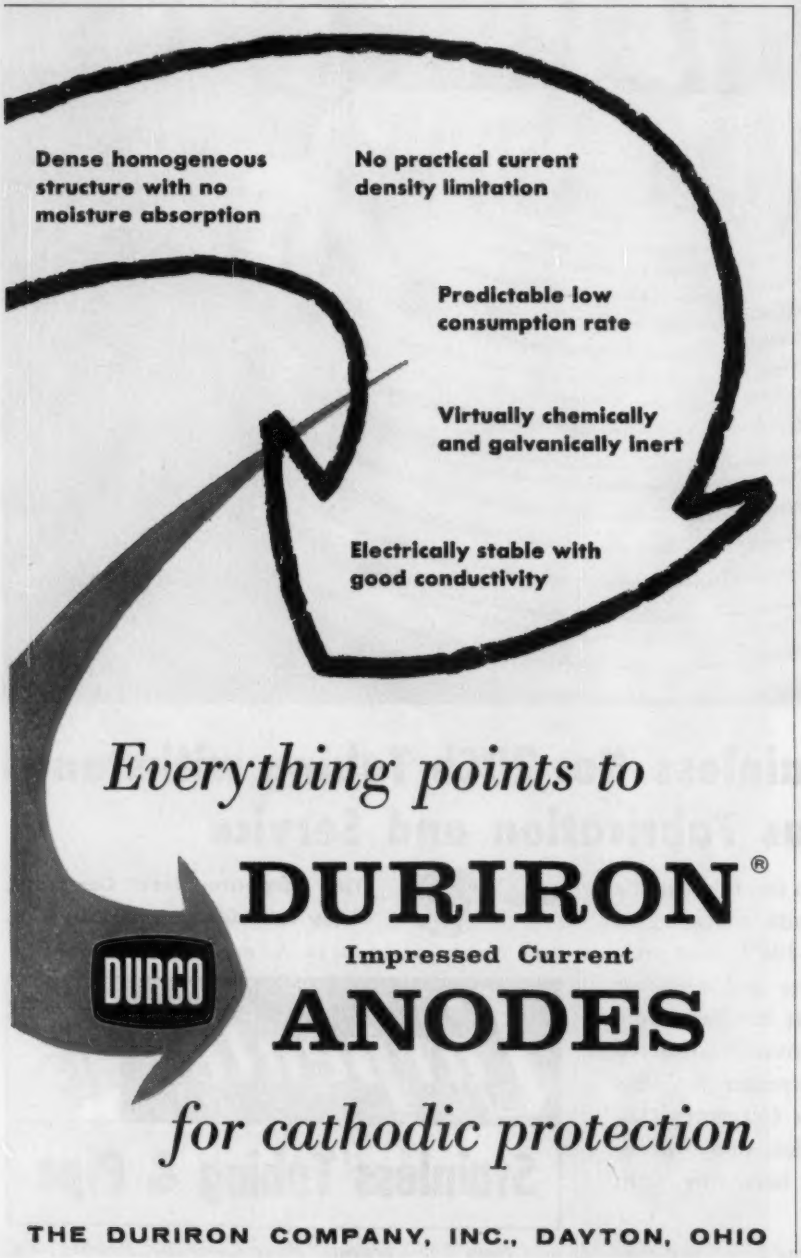
estimates indicate it would be possible for Gulf to earmark as high as a million dollars for a year's educational contributions under qualifications of the new plan and previous programs.

Whiteford said his company felt its new aid to education program was a further fulfillment of its duties as a corporate citizen at a time when American colleges and universities are in need of financial assistance.

The new program continues many features of its past practices and adds new plans which will help increase faculty earnings, encourage alumni to contribute to their colleges, and help colleges and selected departments to meet current expenses.

A new feature of the program is a plan which is designed to provide additional income to teachers of subjects which are of interest to the company. This faculty salary supplementation plan, as designed by Gulf, contains some unique aspects in the field of corporate aids to education especially in the mutual benefits expected to be shared by both the company and teachers.

The six specific features of the aid to education program—applicable to Gulf Oil Corporation and its wholly owned subsidiaries are: Gulf Merit Scholarships, Alumnus Gift Matching Program, Faculty Salary Supplementation Plan, Direct Grants to Independent Colleges, Departmental Assistance Plan and Graduate Fellowship Program.



Profs Study Conoco, Humble

Continental Oil Co., and Humble Oil and Refining Co., have both called upon American educators to study and analyze company operations.

Conoco invited ten professors who participated in a "visiting professors' seminar" last month. At the end of the seminar they made recommendations as to how they believed the company's policies and methods could be improved.

The visiting professors spent the first day with top management exploring management's philosophy and practices, then they spent several days visiting company people and locations in the Southwest, Midwest, and Rocky Mountain areas. Toward the end of the seminar, they privately discussed and summarized their experiences and impressions, then reviewed their findings and recommendations with top management.

Another major, Humble Oil, is also seeking opinions from educators on the company's operations and policies.

Twenty-six professors from 14 universities who have been working on special projects for the company during the summer months were called upon to discuss their experiences and impressions with each other. Then they conferred with Humble management.

Humble also has other professors working in areas away from Houston during the summer months who did not participate.

New Test for Avgas

National Bureau of Standards has developed a new method for estimating combustion heat of aviation gasolines, based on an "empirical equation relating combustion heat to proportion of various hydrocarbon types present."

The Bureau says the method does not require elaborate calculations or extensive analytical work, and is "well within the testing capacity of most oil companies' laboratories." It is expected to aid in checking aviation gasolines for conformance to military specifications.

Interested parties may obtain further information from the National Bureau of Standards, Washington 25, D. C.

'United Europe' Plans for Oil

Three features of particular significance to the oil industry in Europe's six-nation Common Market Treaty were pin-pointed today by Petroleum Industry Research Foundation, now that both Germany and France have ratified the treaty.

Pact's aim is to weld the economic potential of those countries, Italy and Benelux countries into a single unit. This is to be accomplished over a 12-15 year period in which internal tariffs between the six nations are to be gradually abolished, while a new common customs tariff for whole area is to be created.

Particularly noteworthy, said the foundation, are the following aspects of the treaty:

1. "The Common Customs duties for oil and most petrochemical products will not be calculated on the standard basis established for most other products, namely the arithmetic average of their duty in the six member countries. Instead, oil and petrochemicals are included in a series of special lists which contain those products whose Common Customs duty is (or will be) fixed independently of the standard formula. For crude oil the eventual Common

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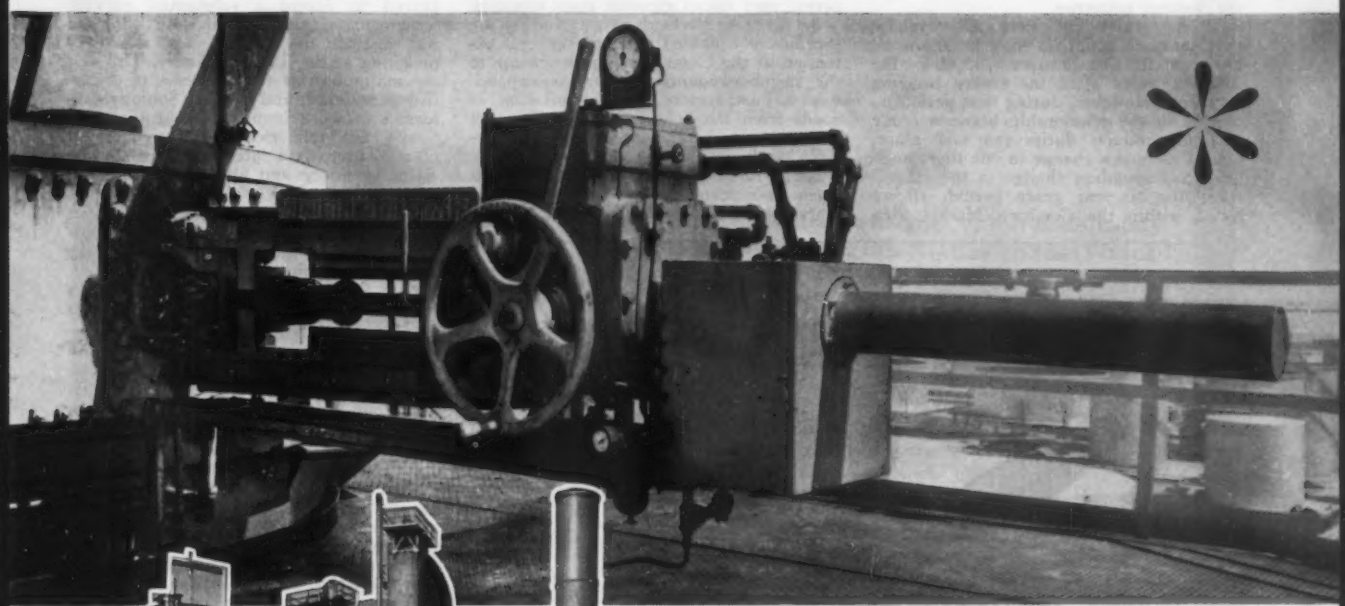
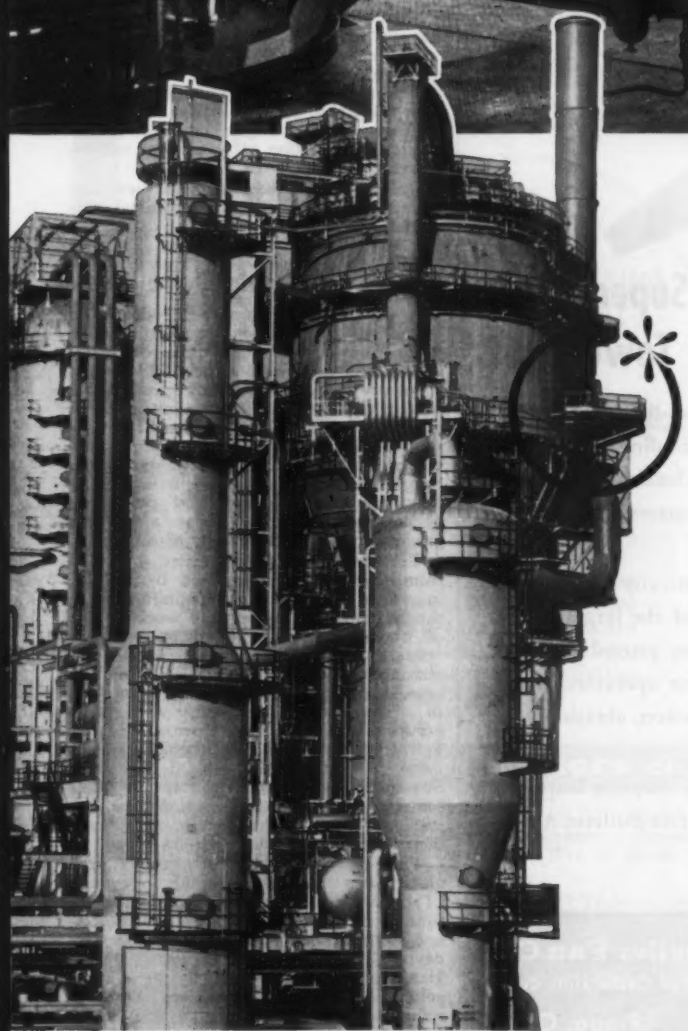
CONTROL STACK VALVES IN WORLD'S MOST MODERN REFINERY





Throughout the world, hundreds of Conoflow Rotomotors are in constant use actuating large stack valves and slide valves. Rotomotors have proved to be the safest, most powerful, and most dependable actuators available for these critical throttling control services.

Seventeen Rotomotors were specified and installed by contractors in Tidewater's new Delaware Refinery—the world's largest integrated refinery.

Photographs show one of a pair of these unique pneumatic actuators operating a 72-inch double disc regenerator vent valve on a large diameter stack, 200 feet above ground on M. W. Kellogg Company's Orthoflow unit. The two Rotomotors actuate opposed sliding valve discs, each covering one-half of the rectangular port opening, 38 inches by 50 inches. Discs travel 25 inches from fully closed to fully opened position. Required positioning accuracy of one part in 400 of stem travel is obtained despite heavy stem load of 18,000 lbs. Assembly is completely air operated, hence explosion-proof.

How the Rotomotor Works . . .

is described with schematic diagrams in Conoflow Technical Bulletin 107-2, available on request. Send for your copy today—it will be mailed promptly.

Conoflow engineers, highly experienced in the application of the Rotomotor, will be pleased to assist you in determining its suitability for your requirements. Write today to Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa. Representatives in principal cities.

Cono-Controls®

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

SUBSIDIARY OF WALWORTH

What's Happening. . .

Customs tariff has been fixed at zero, while for the major refined products it has yet to be specifically negotiated among the member countries.

2. "A special Oil Protocol stipulates that member countries may maintain oil duties in effect on January 1, 1957, for the first six years after the treaty becomes operative. However, during that period no change in the relationship between crude oil and products duties can take place, (i.e. if there is a change in one there must be a corresponding change in the other). After the six-year grace period, all oil duties within the Common Market area are to be abolished, the Common Customs duty on crude oil is to be reduced to zero, while a new Common Customs duty—yet to be negotiated—will apply to major refined products. Member countries who wish to continue to protect their domestic crude oil production after the six-year period may do so through state subsidies.

3. "The Netherlands West Indies are specifically excluded from the general extension of the Common Market scheme to the member countries' overseas dependencies. Furthermore, any importation of goods from the N.W.I. into the Benelux countries may be exempted from all Common Market provisions and may be burdened with duties or other restrictions when re-exported from the Benelux to other member countries."

Here's Real Proof of the Superiority of Hartzite Plastic Cooling Tower Fans

Since Hartzite plastic was introduced in 1941, one leading producer of petroleum products* has purchased 411 Hartzell cooling tower fans with Hartzite plastic blades. This figure does not include the additional units supplied to this customer by the cooling tower manufacturers who use Hartzell fans on their towers.

What better proof could you ask of the superiority of Hartzite plastic fans than this complete acceptance by one of the largest users of such equipment. Beyond all doubt, Hartzite has proved itself to this customer and to thousands of other cooling tower operators as the fan blade material most resistant to vibration, corrosion, abrasion and mechanical damage.

For complete details on Hartzell fans, and how they can help you cut cooling tower maintenance costs, write today for free Bulletin A-111 or call your nearby Hartzell field engineer.

*Name on request.

HARTZELL Propeller Fan Co.
Division of Castle Hills Corp.
909 Thomas Blvd. Piqua, Ohio

Strikers Go Back to Work

Back to work movements continued last month as management and unions at three more companies reached agreement and signed new contracts.

In Cleveland, Standard Oil Co., of Ohio agreed to accept a substantial sum in settlement of the federal court damage suit against the OCAW for secondary picketing at the Toledo refinery. This was the major barrier to conclusion of collective bargaining, and striking Sohioians returned to work immediately at the company's five refineries and petrochemical plant. Three days later, employes at the Toledo refinery and all other plants had returned to work.

In Houston, agreement was reached at Crown Central's 35,000 bpd refinery putting an end to the three-month-old strike of OCAW members.

Both Sohio and Crown Central workers received essentially the same increases which consist of:

1. Six percent pay increase, effective on date of acceptance.
2. Eighth holiday commencing in 1957.
3. Four weeks vacation for employes with 20 years' service.
4. Holiday pay at two and one-half times the regular rate for scheduled hours worked, and two times the regular rate for unscheduled hours.

Striking UMW-represented employes also returned to work at the Ethyl's plant in Baton Rouge following settlement of a six week strike. The strike was called over a dispute concerning manpower assignments; the question of wages was not involved.

During the strike the plant was operated by supervisory and technical personnel.

New Color Scale Developed

A new scale to measure the degree of refinement of petroleum products has been devised by the National Bureau of Standards in cooperation with the ASTM. Glass standards to match the color specifications of the new scale are now being made in this country, and when these standards are put to use, the difficulties and discrepancies inherent in the present method of color-grading petroleum will be largely overcome. Manufacturers and purchasers of petroleum then will have a uniform guide to measure the quality of a product.

The original set of glasses, obtained from abroad and maintained by ASTM, imperfectly duplicates by nonuniform steps the range of oil colors, and working sets of similar glasses are used by most oil refineries. During recent years, inaccuracies obtained upon occasion in color-grading petroleum by these standards gave impetus to a search for other means. A research group within ASTM's Committee on Petroleum Products and Lubricants enlisted the aid of the National Bureau of Standards. So colorimetric specifications for a new set of glass color standards, adjusted precisely to the average color range of petroleum products, were developed.

Three outstanding defects of the original glass color standards were the following: (1) the color scale was not defined in fundamental terms with stated tolerances, and working sets of glasses held by dealers deviated from the master set; (2) the glasses failed to show precisely the average colors of petroleum in various stages of refinement, particularly in the lemon yellow to orange range; (3) the 12 steps on the scale were perceptually nonuniform

For more data on advertised products, use Readers' Service Cards, last page.

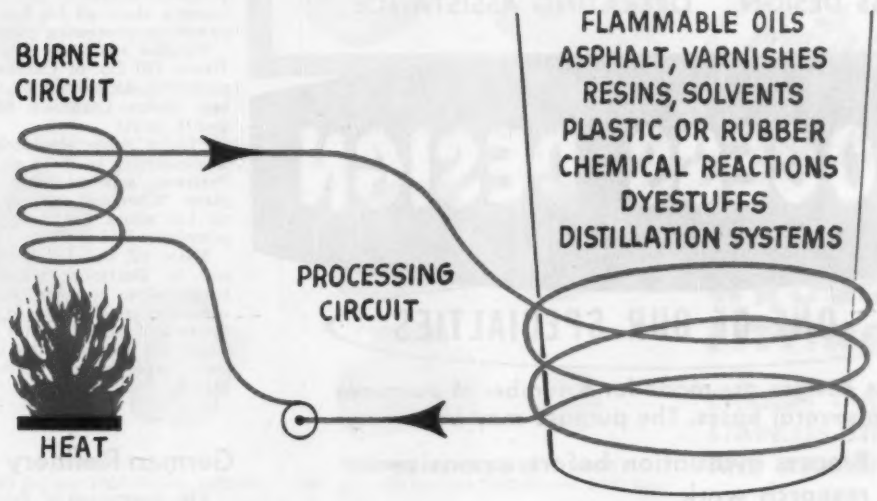
NOW... **NON-PRESSURIZED** LIQUID-PHASE HEAT TRANSFER SYSTEMS THAT OPERATE UP TO **600° F.**

AROCLOR 1248

✔ **Operates at atmospheric pressure** ... cuts installation and maintenance costs of expensive pressurized systems.

✔ **Fluid is fire resistant** ... increases safety by eliminating direct-firing and heat transfer with flammable fluids.

HERE'S PIN POINT CONTROL TO WITHIN 2° F.



The Equipment ... capacities can range from small portable units—usually electrically heated—to large gas- or oil-fired units generating from 250,000 to over 10,000,000 B.T.U.'s per hour. Circuits are closed, forced-circulation. Compact design saves space, minimizes installation and maintenance costs.

The Fluid ... Aroclor 1248 is a highly stable chlorinated polyphenyl; does not support combustion up to its boiling range 652° to 725° F.; is non-corrosive. Aroclor 1248 operates in most systems four to seven years without replacement.

Aroclor: Reg. U. S. Pat. Off.

Contact Monsanto for SOURCES of AROCLOR 1248 heating systems

MONSANTO

Where Creative Chemistry Works Wonders For You

MONSANTO CHEMICAL COMPANY, Organic Chemicals Division
Department IF-1, St. Louis 1, Missouri

Gentlemen:

Please send: ☐ Technical information about Aroclor 1248
☐ Names of designers and manufacturers of Aroclor 1248 operated equipment

Name.....

Firm..... *Address*.....

City..... *State*.....

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What's Happening . . .

so that inaccuracies occurred when a sample of petroleum was compared visually with a standard nearly matching it. As a result of these defects, when a purchaser of partially refined petroleum which was specified as color number 3 on the color scale, found by his own measurement that it was really color number three and one-half, he was forced at considerable expense to refine his purchase to the desired degree.

In setting up the new color scale, the Bureau measured the colors of 49 samples of petroleum in the pale yellow to orange range. Based on these measurements, a relocated and respaced color scale was calculated. As soon as the scale was submitted to the ASTM Committee, the Committee's research group directed its effort toward finding reliable sources of supply in this country for sets of glass color standards to fit the specifications.

In April 1957 the research group of the Committee approved a new tentative method for color-grading petroleum products based on the revised color scale. This decision was made after extensive cooperative tests showed that agreement between laboratories using the revised color scale was possible. Formal approval of the new method by the Committee on Petroleum Products and Lubricants was announced at the recent ASTM annual meeting in Atlantic City.

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Process designs are made for a number of purposes and on several bases. The purpose may be

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Process design is alternately based on

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THE C. W. NOFSINGER COMPANY
Engineers and Contractors for the Petroleum and Chemical Industries
906 GRAND AVENUE KANSAS CITY 6, MISSOURI

Tidewater to Train Eight Volunteer Fire Companies

Eight Delaware volunteer fire companies will be trained in the specialized techniques of fighting oil fires during special courses to be conducted at the fire-fighting school of Tidewater Oil Company's new Delaware Refinery.

Announcement of the program was made today by Leslie C. Johns, chief of the refinery's fire department, who said that the plan will work out as a mutual aid program. The volunteer firefighters will be better prepared to cope with oil fires in their own districts, he pointed out, while an outside reserve of trained men will be available to augment the refinery's fire department in the event of emergency.

The courses will be conducted on weekends, for the convenience of the volunteers. The training will be of aid to the volunteers in helping them to better combat burning oil tanks, automobile fires, service station blazes or any fires involving petroleum products.

Shale Oil Being Used Now

Union Carbide Nuclear Co. is now burning shale oil for fuel at its uranium-vanadium processing plant at Rifle, Colo.

Surplus shale oil being produced at Union Oil Co. of California's pilot plant at nearby Grand Valley, Colo., is supplying Union Carbide's 60,000 gallons a month needs.

"We've made absolutely no alterations in converting to shale oil," said Harry C. Peterson, superintendent of the nuclear plant. "Chemical analysis shows that shale oil has about the same caloric value as petroleum fuel oil."

Shale oil use by Union Carbide will end in December when Union Oil is scheduled to complete its current experimental runs. Union uses shale oil also to fire boilers at its Grand Valley pilot plant, which has produced about 250,000 gallons since experimental operations began in March.

German Refinery Runs Up

The Association of Petroleum Industry expects West German refineries to run 19.4 percent more crude to stills in 1958 than predicted for this year—16 million tons as against 13.4 million.

At the same time, the association expects domestic crude's more than one-third share of runs to drop to less than one-fourth. It expects that 3.8 million tons of domestic crude and 12.2 million tons of foreign crude will be processed.

El Paso Seeks Merger O. K.

El Paso Natural Gas Co. has asked the Federal Power Commission to approve a merger with Pacific Northwest Pipeline Corp., whose stock El Paso acquired early this year.

The Justice Department on July 22, filed a complaint in the U. S. District Court in Utah against the two companies alleging that El Paso's acquisition of more than 99 percent of the outstanding stock of Pacific Northwest was in violation of Clayton Act's Section seven.

The DJ complaint alleged that the acquisition "may substantially lessen com-

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IPS—BUTT WELDING FITTINGS
½"-42" From Sch. 5S to 4" Walls

ASA and MSS FLANGES
½"-24" 150 through 2500 lbs.

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TUBE O.D.—BUTT WELDING FITTINGS
½"-36" From .049" to .250" Wall

LARGE O.D. and TEMA FLANGES
Up to 20' in Diameter

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1"-24" 150 through 2500 lbs.

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LADISH

FOR *Complete Service* IN *Controlled Quality*

FORGED AND WROUGHT FITTINGS

CARBON • ALLOY
STAINLESS STEELS
AND ALUMINUM

WHATEVER your fittings requirements . . . regardless of the type, size, wall thickness, pressure rating or material specification . . . you can get prompt, efficient, *complete service* by specifying LADISH and ordering from your local Authorized Ladish Distributor.

A broad, full-range line produced to unsurpassed standards of metallurgical and manufacturing integrity . . . plus adequate distributor stocks . . . gives you double assurance of satisfaction.

For complete service on your fittings requirements . . . call your Authorized Ladish Distributor.

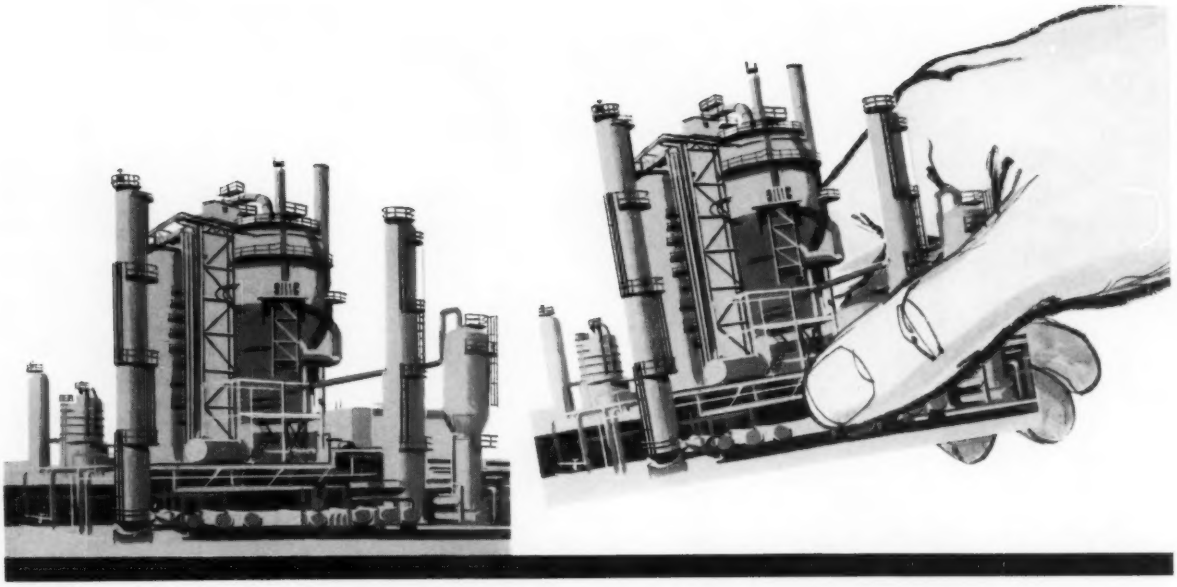
Catalogs available on request. Please indicate specific product lines for which information is desired.

THE COMPLETE *Controlled Quality* FITTINGS LINE

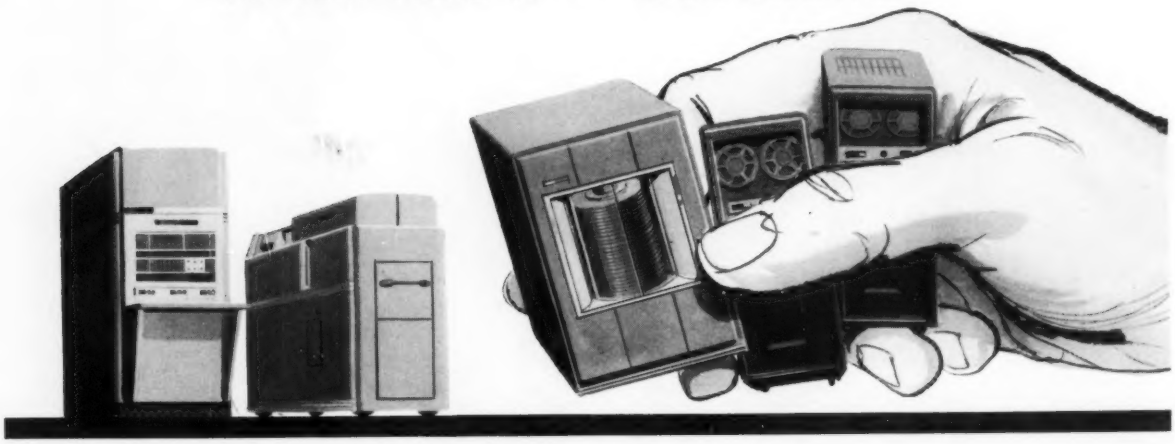
LADISH CO.

CUDAHY (Milwaukee Suburb) WISCONSIN

District and *Regional Offices: New York • *Baton Rouge • Buffalo • Pittsburgh • Philadelphia Cleveland • Chicago • St. Paul • St. Louis • Atlanta • Houston • *Odessa • Tulsa • Denver Los Angeles • *San Francisco • *Seattle • Havana • Mexico City • Brantford, Ont.



TO KEEP PACE WITH YOUR GROWTH



THE **IBM 650** "BUILDING BLOCK" PLAN

With the IBM 650 you gain the *extra* advantage of an electronic system designed on flexible "building block" lines. A compact, self-contained processing unit, your basic IBM 650 can be added to as your refinery engineering and accounting needs grow—using magnetic tape units, RAMAC* disk memory and other optional features.

Prepare for expansion now with a versatile IBM 650 that can grow with you—and help you retain *tight management control* in the face of increasingly complex management, engineering and accounting problems.

Get this "building block" story from your local IBM representative or write: PETROLEUM DEPARTMENT A57-c, International Business Machines Corporation, 590 Madison Ave., New York 22, N. Y.

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*® Random Access Method of Accounting and Control

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What's Happening. . .

petition or tend to create a monopoly" in that it "eliminates the only major pipe line competitor with El Paso" in purchase of natural gas, and "only" competition in sales of gas in several Western states.

On the other hand, Paul Kayser, president of El Paso, said the company is "confident that the Clayton Act relied upon by the Attorney General was never intended to deprive the consuming public of the benefit of such coordinated activities, supervised as it is by a federal agency established by Congress for that purpose. Millions of gas customers would inevitably pay higher costs for their service, and could suffer from diminishing supplies of gas, should the Attorney General's interpretation prevail."

OCAW Drives for Pensions

A resolution calling for a "concerted drive in the oil industry for a pension and welfare plan financed wholly by the oil industry," was adopted last month by delegates to the Oil, Chemical & Atomic Workers convention in Chicago.

The Union plan calls for a pension of two-thirds of an employes regular wage when he reaches the age of 60 (exclusive of social security) or when he has 30 years of service, whichever occurs sooner. It would also like to have financial help for employes in case of prolonged sickness of the worker: financial help in case any member of the family is striken with polio; provisions to take care of a family with children in cases of untimely death of the breadwinner; care taken for burial of those employes who are unmarried or who have no family; and financial help in case of layoffs to tide over a family until the breadwinner can get employment elsewhere.

June LPG Stocks Up

Underground stocks of liquefied petroleum gases on June 30, totaled 672 million gallons according to a report by the Bureau of Mines. This is an increase of 101 million gallons during the month.

Of the total, 567 million gallons were concentrated in Alabama, Mississippi, Louisiana, Texas, and New Mexico. The remainder was in New York, Michigan, Illinois, Kansas, Oklahoma, and Montana.

Underground stocks of propane totaled 389 million gallons, an increase of 71 million; butane increases 253 million gallons, a hike of 25 million; and butane-propane mixture was 30 million gallons, up 5 million gallons.

Fast Tax Write-Offs Killed

The Senate has approved a bill to put an end to the fast tax write-off program by Dec. 31, 1959. Even now though, all defense expansion "goals" for oil and gas facilities have been suspended except for pipe lines and storage with direct defense ties. From now on, only those projects essential to the defense system can be given tax amortization certificates by the Office of Defense Mobilization.

The bill is expected to receive speedy approval in the House.

Esso Cracker Sets Record

A giant cat cracker at Esso Standard Oil Co.'s Bayway refinery, has set a record for the company and all other affiliates of Standard Oil Company (N. J.), by running more than 100,000 barrels of oil in a single day.

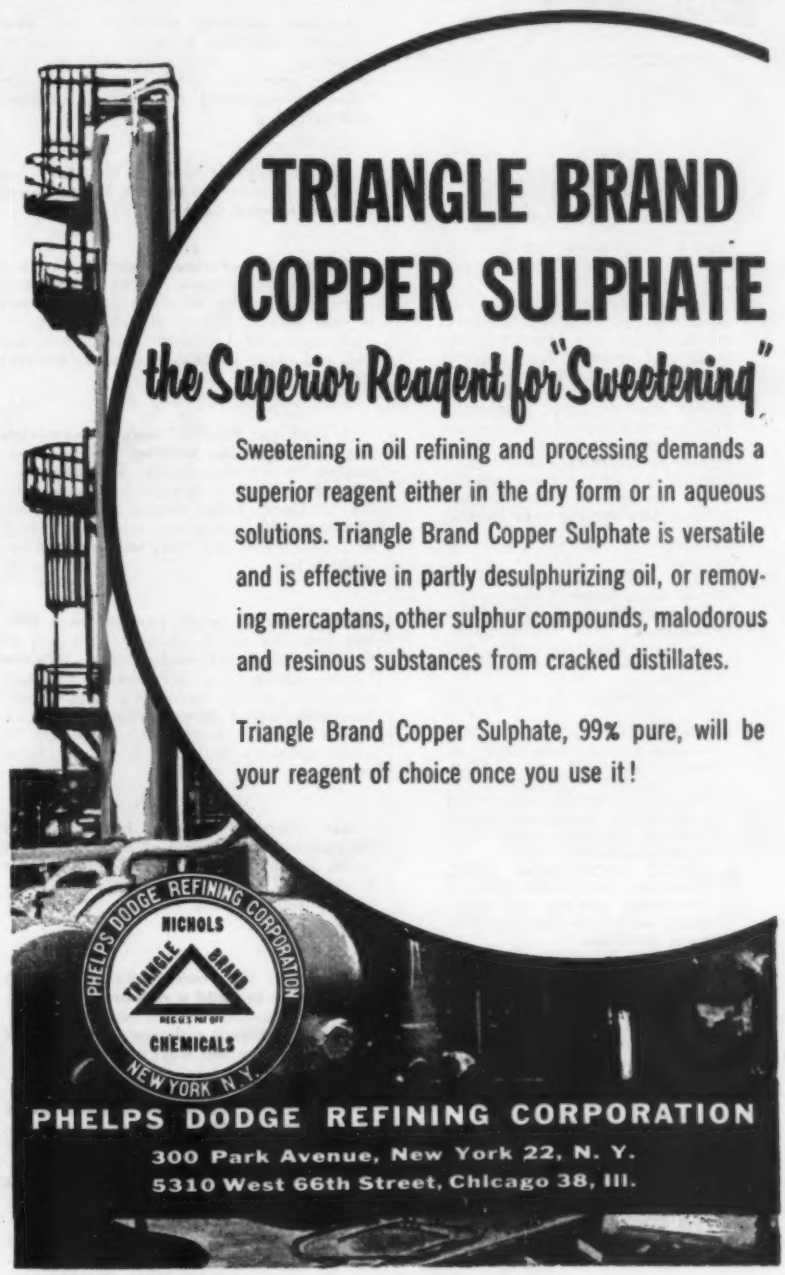
It was the first time in Jersey Standard's 75-year history that one of the big cat crackers reached or exceeded 100,000 barrels a day of total feed.

The Model III unit at Bayway refinery went on stream in August, 1949, and was originally designed for a feed rate of 43,200 barrels. It has had six runs, the longest of which was 21 months.

In April, 1956, the unit was vastly expanded and its design capacity was raised to 82,700 barrels. It went back on stream in June of that year and has been improving its record steadily in the quantity of feed handled.

The Model III cat cracker was designed by the Esso Research and Engineering Co. and is a modification of a Model II unit at Esso Standard Oil Co.'s refinery in Baton Rouge.

Be Sure to Read "Changing Times" Just Turn to the Next Page


TRIANGLE BRAND
COPPER SULPHATE
the Superior Reagent for "Sweetening"
Sweetening in oil refining and processing demands a superior reagent either in the dry form or in aqueous solutions. Triangle Brand Copper Sulphate is versatile and is effective in partly desulphurizing oil, or removing mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates.
Triangle Brand Copper Sulphate, 99% pure, will be your reagent of choice once you use it!
PHELPS DODGE REFINING CORPORATION
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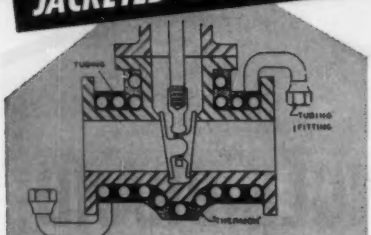
For more data on advertised products, use Readers' Service Cards, last page.

Thermon

The Revolutionary New Solid

HEAT TRANSFER MEDIUM

SAVINGS UP TO 75% over JACKETED EQUIPMENT



Typical Thermonized Valve Section

Thermon, the product, and Thermonizing, the process, represent a revolutionary new concept in the science of external heat application. Thermon is a non-metallic plastic compound with highly efficient heat transfer properties, and is easily applied in a viscous paste form over either steam traced or thermal electric systems. It completely surrounds the tracer tubing and conducts heat to the entire surface to be heated.

Definite Advantages of Thermonizing are:

1. LOW COST—save up to 75% over equal jacketed equipment.
2. EXCELLENT HEAT TRANSFER—Exceeds steam traced equipment approximately 1100% and very closely approaches jacketed equipment.
3. DEPENDABILITY—no hot or cold spots.
4. WIDE TEMPERATURE RANGE—used for sub-zero cooling or heating to 750°F.
5. NO JACKET PLUGGAGES OR PRODUCT CONTAMINATION—in case of equipment failure, Thermon separates product from heating medium.
6. GOOD MECHANICAL AND THERMAL SHOCK RESISTANCE—cracking, spalling, and degradation are all nil—less than 1% linear shrinkage.
7. ADAPTABLE—may be used with either steam traced or thermal electric equipment—installed at our shops or your job location.
8. RAPID DELIVERY—use of standard equipment permits minimum delivery time.

Write for comprehensive brochure about revolutionary Thermon!

THERMON MFG. CO.
1017 Rosine • P.O. Box 1961
Houston, Texas

Changing Times

Arizona governor wishes that someone would **build a refinery in Arizona.** State Development board is pursuing the matter further by appointing a committee to **figure which kind of bait to use.**

A "fully competitive" synthetic rubber industry is shaping up "slowly," Attorney General Brownell recently reported to Congress. **What still worries him though** is the "continuing price rigidity and uniformity," Shell Chemical's lack of competition on the West Coast, and the fact that small business' share in the industry has not grown in proportion to industry as a whole.

Largest synthetic rubber tires ever manufactured have been sent to Army by Firestone. After testing similar tires of a smaller size last year, Army said they **"met or exceeded all military requirements."**

Eastern States Petroleum Co., Inc., has changed its name to **Eastern States Petroleum & Chemical Corp.**

Oklahoma Agricultural and Mechanical College, better known as Oklahoma A&M since its founding 66 years ago, **now has a new name.** School Broad of Regents with approval by State Legislature has changed name to **Oklahoma State University.**

A Michigan "model" **ordinance restricting service station building has been repealed** by one community. The ordinance was also under test in a pending court case. Circuit Court Judge termed the ordinance "unreasonable, arbitrary, and capricious," and added that the **"city did right in repealing it."**

There will be no six percent wage hike this year for O. A. Knight, president of the Oil, Chemical, and Atomic Workers Union—or for any member of his staff either. At recent convention in Chicago, **delegates voted down proposal** to give Union officials wage increase equal to what members received from oil companies.

Esso Standard Oil Co. has processed the two-billionth barrel of crude oil at its Baton Rouge refinery. First billion barrels required 37 years—from 1909 to 1947. Second billion went through in just 11 years.

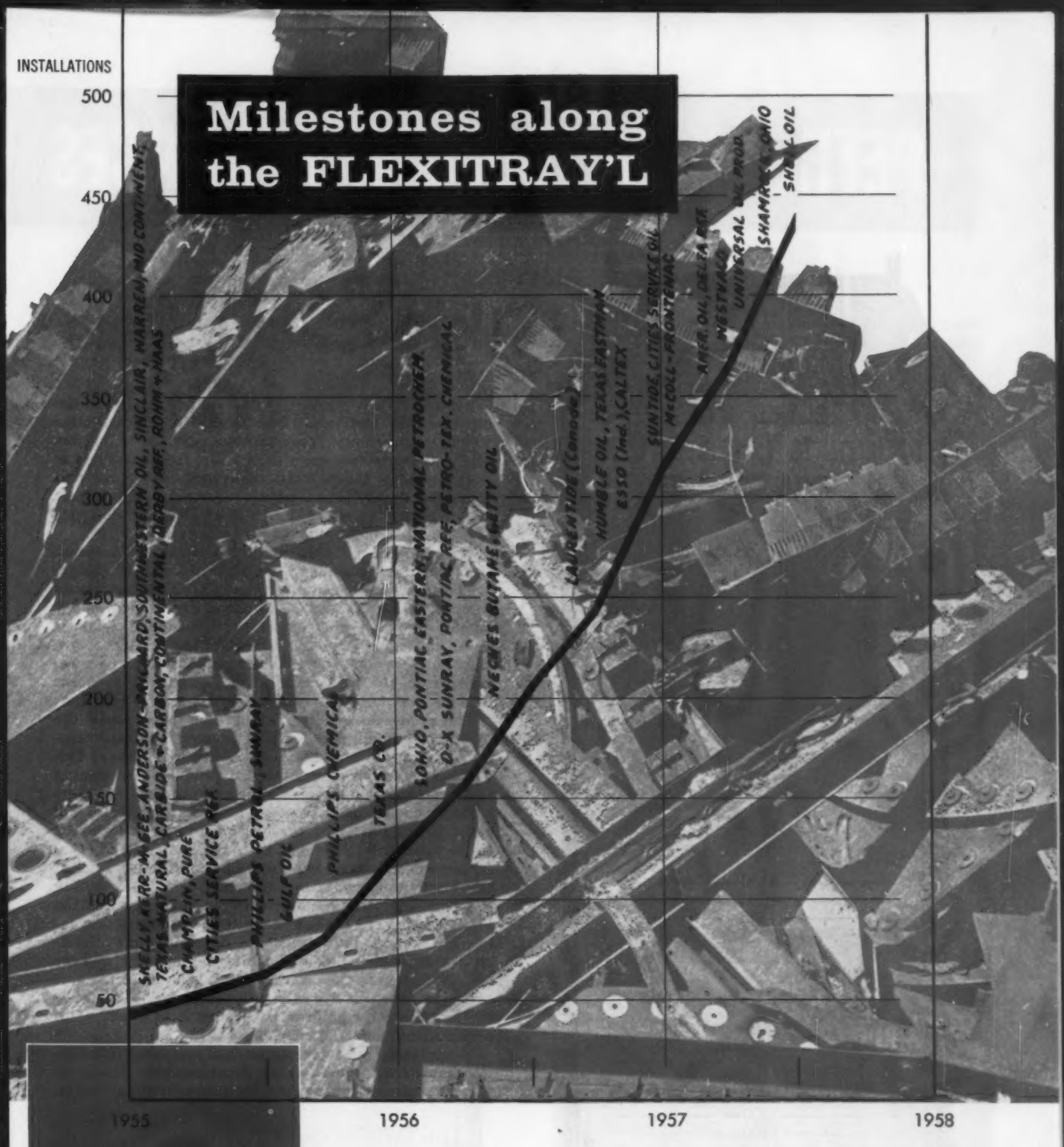
After more than two years of frustration in its **efforts to build a refinery in Hawaii,** California-Standard is still bound head-to-foot in government red tape. **Result: plant may wind up on the west coast.**

Sun Oil Co., has **added a sixth grade** to its custom blended gasoline . . . **oil industry must have a capital investment** of $40,000 to $60,000 for every employe—for all industry the average is $17,000 . . . Badger Manufacturing Co. has established **Canadian Badger Co., Ltd.** . . . motor fuel tax collections by states for last fiscal year amounted to **$16.96 per person.**

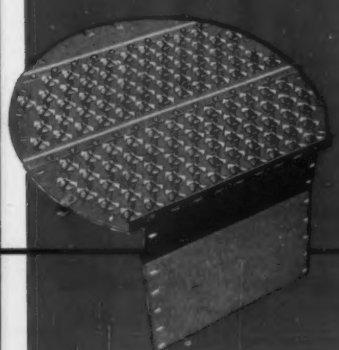
MEETINGS CALENDAR

SEPT.	
15–18	**American Institute of Chemical Engineers, Lord Baltimore Hotel, Baltimore.**
22–25	**The 12th Annual Petroleum Mechanical Engineering Conference, ASME, Mayo Hotel, Tulsa.**
23–25	**American Society of Mechanical Engineers, Fall Meeting, Statler Hotel, Hartford, Conn.**
26–27	**Western Petroleum Refiners Association, Rocky Mountain Regional Technical-Industrial Relations Meeting, Henning Hotel, Casper, Wyoming.**
27	**Natural Gasoline Association of America, Oklahoma Regional Meeting, Skirvin Hotel, Oklahoma City.**
30–Oct. 2	**American Oil Chemists' Society, 1957 Fall Meeting, Netherland Plaza Hotel, Cincinnati.**
OCT.	
1– 4	**National Association of Corrosion Engineers, North Central Region in Sherman Hotel, Chicago; South Central Region in City Auditorium, Oklahoma City.**
7– 9	**ASLE-ASME Lubrication Conference, Chateau Frontenac, Quebec, Canada.**
7– 9	**American Gas Association, Annual Convention, Kiel Auditorium, St. Louis, Mo.**
7–11	**American Institute of Electrical Engineers, 1957 Fall General Meeting, Morrison Hotel, Chicago.**
9–11	**Fourth Annual Symposium of High Vacuum Technology, Hotel Somerset, Boston.**
10–11	**California Natural Gasoline Association, 32nd Annual Fall Meeting, Huntington-Sheraton Hotel, Pasadena, California.**
10–12	**ASME, Fuels-AIME Conference, Chateau Frontenac, Quebec City, Que.**
16–18	**American Society for Quality Control, New England Sections, 11th Annual Conference, Stratfield Hotel, Bridgeport, Conn.**
18	**American Institute of Chemical Engineers, South Texas Section, 12th Annual Technical Meeting, Moody Convention Center, Galveston.**
22–24	**National Association of Corrosion Engineers, Seventh Annual Western Regional Conference, U.S. Grant Hotel, San Diego.**
24–25	**Western Petroleum Refiners Assn., Regional Technical-Industrial Relations Meeting, Rufus Garrett Hotel, El Dorado, Ark.**
24–25	**Fourth Annual Computer Applications Symposium, Sponsored by Armour Research Foundation, Hotel Sherman, Chicago.**
25	**Natural Gasoline Association of America, Southern Regional, Washington-Youree Hotel and Captain Shreve Hotel, Shreveport, La.**
28–29	**Annual Meeting, National Lubricating Grease Institute, Edgewater Beach Hotel, Chicago.**
28–31	**American Nuclear Society, Second Winter Meeting, Henry Hudson Hotel, New York**
NOV.	
6– 8	**Society of Automotive Engineers, National Fuels and Lubricants Meeting, Hotel Statler, Cleveland.**
11–14	**American Petroleum Institute 37th Annual Meeting, Conrad Hilton and Palmer House, Chicago.**
12–14	**National Association of Corrosion Engineers, Northeast Region Fall Meeting, Penn-Sheraton Hotel, Pittsburgh.**
13–14	**Air Pollution Conference, Armour Research Foundation and Midwest Air Pollution Prevention Association, Chicago.**
13–16	**National Association of Corrosion Engineers, Miami Section, Key Biscayne Hotel, Key Biscayne, Fla.**
22	**Natural Gasoline Association of America, Panhandle Plains Regional Meeting, Herring Hotel, Amarillo.**
DEC.	
1– 6	**American Society of Mechanical Engineers Annual Meeting Statler Hotel, New York.**
8–11	**American Institute of Chemical Engineers Annual Meeting Conrad Hilton Hotel, Chicago.**

Milestones along the FLEXITRAY'L



*Dates of original orders only, reorders not shown.



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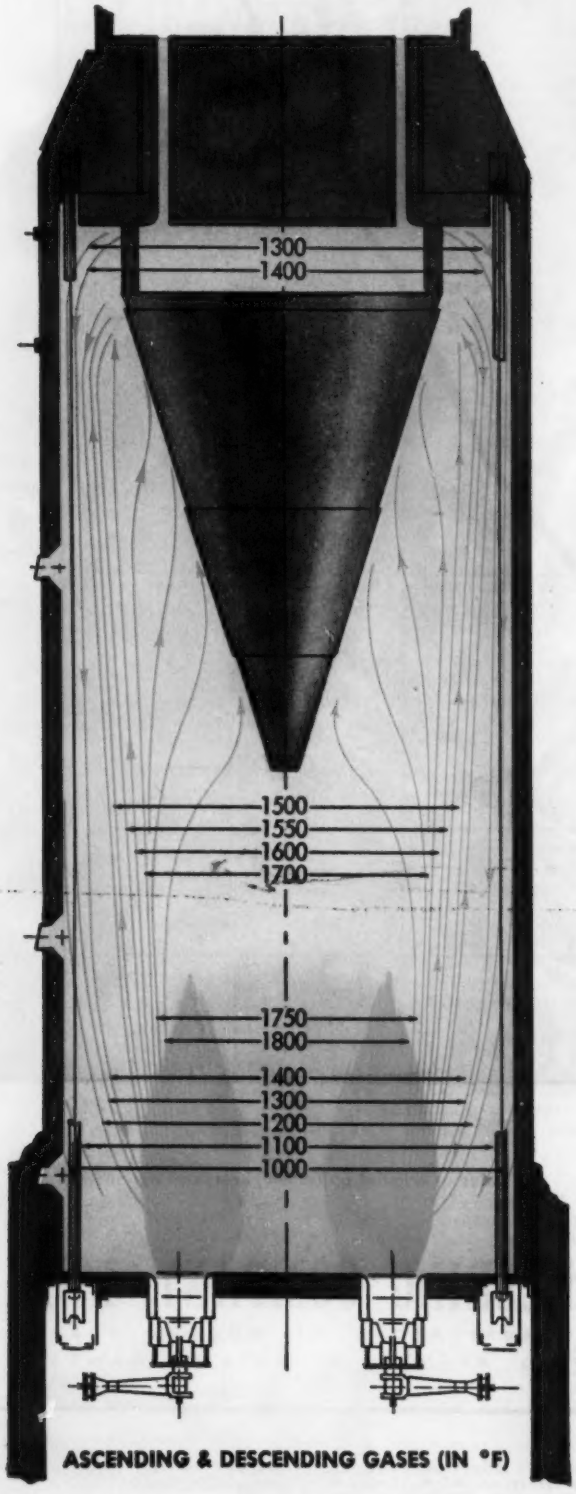
PETROCHEM-ISOFLOW FURNACES



ASCENDING & DESCENDING GASES (IN °F)

Here are the facts!

The first vertical cylindrical heaters provided even circumferential heat input, but vertical flux distribution varied considerably, from high transfer at the bottom of the tubes to low rates at the top. Improvements in design during the past twenty years have overcome this difficulty, by providing proper firebox proportions, a reradiating cone, and burners specifically designed to the requirements of the furnace.

It is significant that *only Petrochem-Isoflow furnaces* incorporate all three of these critical items of design.

The small, hot cone tip reradiates to the tubes, across a considerable distance. Because of the conical shape employed, each higher element of the cone is of larger area, and closer to the tubes than the section below. These factors compensate for decrease in cone temperature from tip to base, provide relatively constant radiant heat transfer over entire upper tube length.

The cone also serves to divert flue gases along the upper ends of tubes, which adds convection heat transfer over this length. It also initiates a high rate of firebox recirculation of combustion products, by cooling the gases in their passage across the tubes.

Being cooler, and therefore heavier than the rising gases in the center of the firebox, the gases adjacent to the tubes fall to the bottom of the heater by thermal siphon effect, increasing the heat input to the rear of the heating elements by convection. The descending gases also serve as a buffer between hot gases and the lower ends of the tubes and dilute the products of combustion. The special burners, by developing a symmetrical flame pattern, contribute to the equality of heat distribution over the entire radiant tube length.

Of the design features mentioned above, the cone is of the greatest significance because it is essential to even radiant heat distribution.

Experienced operators know that even heat distribution improves product quality, decreases tube deteriorations, results in longer, trouble-free operating cycles.

The Data Shown in the Drawings are ACTUAL PERFORMANCE RECORDS!

To check radiant flux distribution in Petro-Chem furnaces, exhaustive tests were made under actual operating conditions; some of the results of these tests are indicated in the two adjacent drawings.

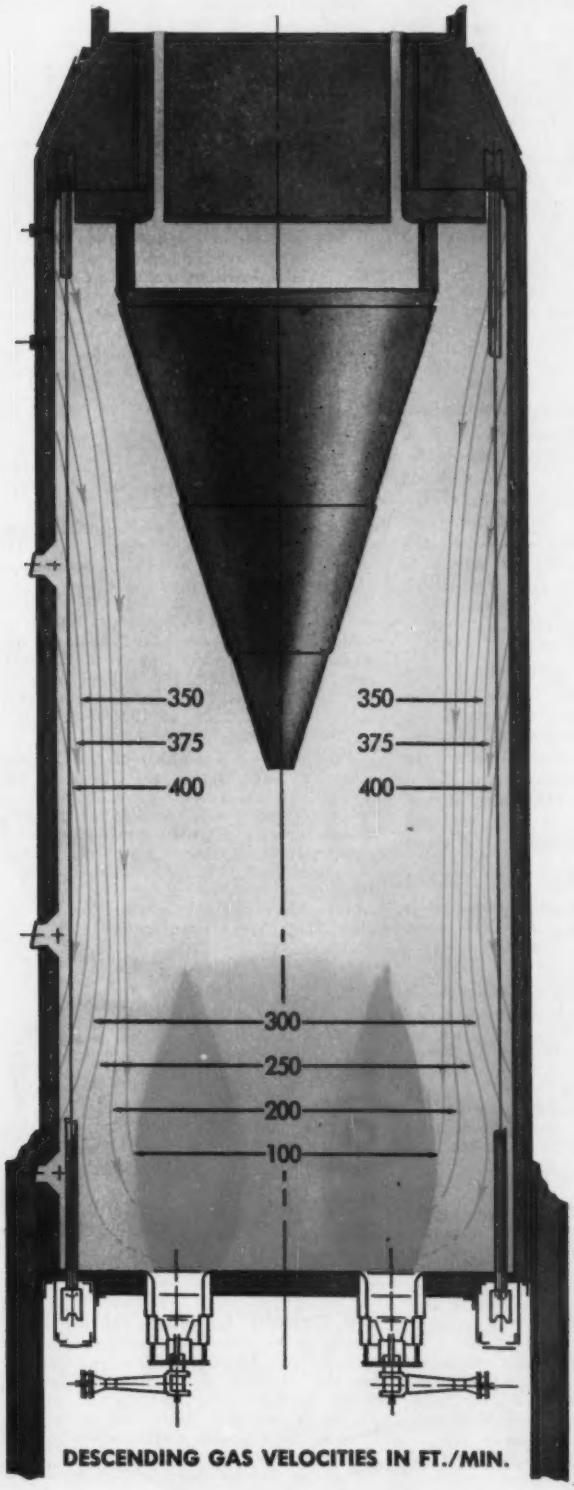
Left: Plot of isotherms in a Petrochem-Isoflow firebox, illustrating the uniformity of firebox temperature.

Right: Plot of flue gas flow patterns and velocities, demonstrating the high gas recirculation rates.

Both of these phenomena are the result of proper firebox proportions, the two-fold action of the cone, and symmetrical flame pattern.

For more data on advertised products, use Readers' Service Cards, last page.

Provide EVEN HEAT Distribution !



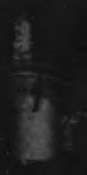
DESCENDING GAS VELOCITIES IN FT./MIN.

In addition to even heat distribution, other all-important factors which determine the value and efficiency of processing furnaces include:

MAXIMUM FUEL EFFICIENCY
PLENUM CHAMBERS FOR HAZARDOUS AREAS
SIMPLICITY OF DESIGN AND CONSTRUCTION
EXCESS DRAFT FOR HIGH OVERLOAD
EXPLOSION RESISTANT
MINIMUM GROUND SPACE
SHORT LENGTH OF LIQUID TRAVEL
ZERO AIR LEAKAGE
LOW PRESSURE DROP
LOW MAINTENANCE

In every case where these 11 all-important design characteristics were employed to compare one type of furnace design with another, PETROCHEM-ISOFLOW FURNACES were proved more economically desirable by any comparison.

More than 1350 Petrochem-Isoflow Furnaces have been installed since 1940—an unequalled record of acceptance based on proved performance.



PETROCHEM —ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT COMPANY, INC.
122 East 42nd Street, New York 17, N. Y.

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For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

. . . *Among Men* in the Industry

Loudon

Stephens

John H. Loudon has been elected chairman of the Shell Oil Co. board of directors. He succeeds **Sir Francis Hopwood,** who retired June 30.

F. J. Stephens was elected to fill the vacancy on the board resulting from Hopwood's retirement.

Loudon is president of the Royal Dutch Petroleum Co. and chairman of the board of the Shell Caribbean Petroleum Co. He was first elected to the Shell Oil Co. board of directors in 1948.

Stephens is a managing director of The "Shell" Transport and Trading Co., Ltd., The Shell Petroleum Co., Ltd., and N. V. De Bataafsche Petroleum Maatschappij.

Bruce A. Eckerson has been named to the new position of process engineer in Signal Oil and Gas Co.'s gas department. Eckerson was an engineer with California Research Corp. for 12 years. His work there included research, design, and development in the field of gas processing. In 1942 he graduated from UCLA, where he later received his M.S. degree in chemistry.

Hamilton P. Caldwell, Jr., has been named manager of Socony Mobil Oil Co.'s refinery in Augusta, Kans. Caldwell, who has been manager of the company's refinery in East Providence, R. I., will succeed **J. W. Glass,** who is retiring after 37 years of service.

Joseph E. Penick, supervisor of light oil operations in the manufacturing department, has been named manager of the East Providence refinery.

Bonner H. Templeton, assistant manager of Socony Mobil's process promotion division, will succeed Penick.

J. H. McClintock and **A. A. Sanders** have been promoted to senior chemical engineers in Technical Service division and **J. A. Snyder** and **E. L. Wilson,** to senior research chemical engineer in Research and Development division at Humble Oil & Refining Company's Baytown, Texas, refinery.

McClintock and Sanders hold B.S. degrees in chemical engineering from Texas University; Wilson, a B.S. degree in chemical engineering from Texas A & M College; and Snyder, B.S. and M.S. degrees in chemical engineering from Tulane University.

R. L. Hockley, a consultant in the chemical industry, has been elected to the board of directors of Amoco Chemicals Corp. where he will devote a substantial portion of his time to study and counsel on all management matters at Amoco, including particularly development and marketing.

His early career included positions with W. W. Lanahan Co., Worthington Pump and Machinery Co.; G. D. Penniman, Jr. & Associates; and The Davison Chemical Corp., of which he was president. He was vice president of Olin Mathieson Chemical Corp. from 1954 to early 1957.

Hockley attended the Baltimore Polytechnic Institute, Phillips Andover Academy, and Cornell University at Ithaca, N. Y. He has been connected with the chemical industry for over 20 years.

Dr. Hal B. Coats has been named assistant manager of the Midwest headquarters at Chicago of the Chemical Plants division of Blaw-Knox Co., Pittsburgh. A veteran of 15 years with Blaw-Knox, Dr. Coats has served as Research and Development director of the Chemical Plants division and manager of its Atomic Energy department. He has contributed many significant developments to chemical processing including vegetable oil extraction, liquid-solid extraction, liquid-liquid extraction, nuclear test reactors, shielding, materials separation and waste disposal.

Coats

Dr. Coats received his Ph.D. degree from the University of Michigan, and is a registered professional engineer in Pennsylvania and Michigan.

John C. Starr has been named president and director of the newly established Canadian Badger Co., Ltd., in Toronto. **Adrian J. Broggini** and **William C. Rousseau** were named directors. Starr was born in Canada and attended McGill University and the Massachusetts Institute of Technology. He is also vice president in charge of engineering and construction for the parent company.

Dr. John J. McKetta, chairman of the PETROLEUM REFINER Editorial Committee was elected to the board of trustees of Tri-State College, Angola, Ind. Dr. McKetta is Chairman of the Chemical Engineering department of The University of Texas. in 1936 he received the Most Distinguished Alumni Award from Tri-State College.

Dr. McKetta received his B.S. degree in chemical engineering from Tri-State College in 1937 and later his M.S. and Ph.D. degrees from the University of Michigan.

In 1953 he was named as a Distinguished Alumnus by the University of Michigan.

John H. Dea has been named assistant to the president of The Texas Co. Dea has been assistant manager of the Sales division of Texaco's Foreign Operations department-Western Hemisphere and West Africa since November, 1956.

He graduated from the University of Notre Dame in 1930 with a B.S. degree in chemical engineering. He joined Texaco in 1937 as an industrial salesman in the Minneapolis Sales division. Beginning in 1942 he served four years in the Air Force, and upon his return to Texaco, served as supervising engineer at Milwaukee, chief lubrication engineer in Denver, and from 1952 to 1955 was assistant division manager (Industrial Sales), Minneapolis. In November, 1955, he was named assistant to the vice president, Foreign Operations department-Western Hemisphere and West Africa.

Irb H. Fooshee has been named executive vice president and James G. Fox, Jr. vice president of General Chemical division, Allied Chemical & Dye Corp.

Fooshee has been vice president in charge of development since 1954. He joined the company in 1947 as assistant to the president, subsequently serving as director of operations and director of development. Prior to joining General Chemical, he was vice president of Neches Butane Products Co., Port Neches, Texas, and was affiliated with Rubber Reserve Co., Washington, D. C. He graduated from Texas A. & M. in 1929 with a B.S. degree in chemical engineering.

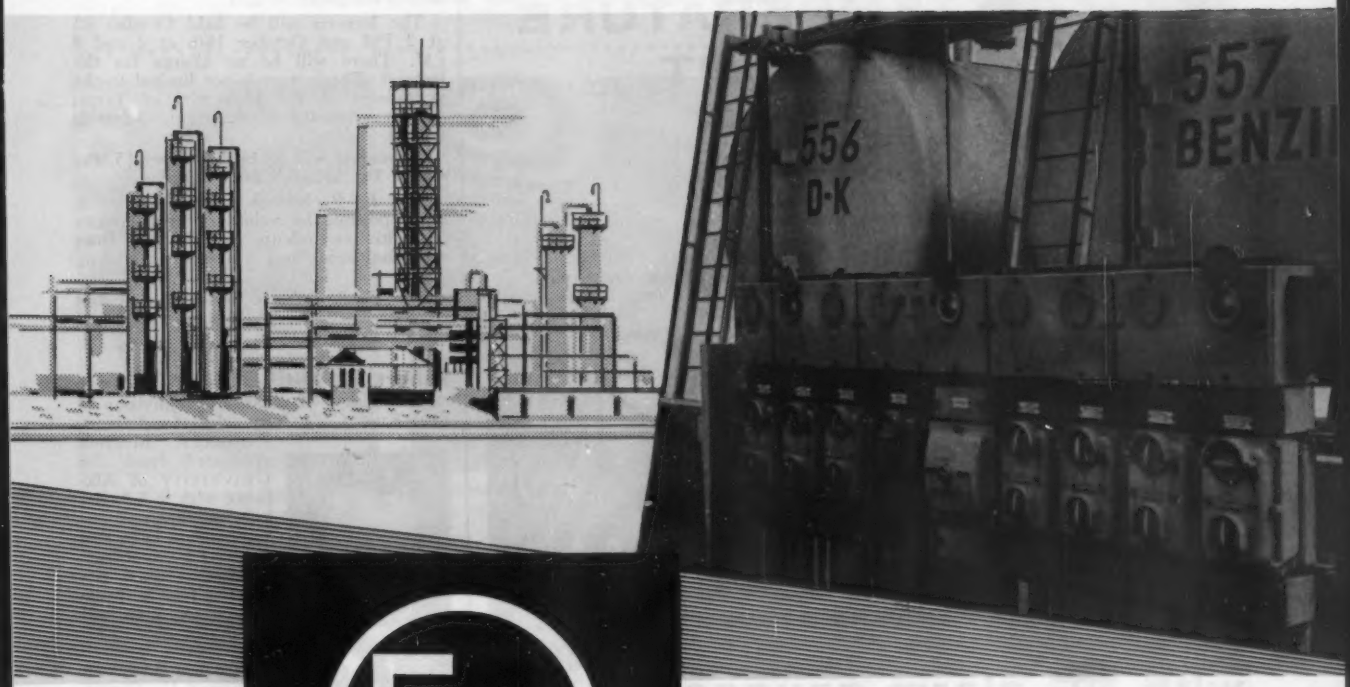
Fox has been a member of the General Chemical organization for 31 years, the last 20 of which have been as assistant works manager, assistant director of operations, director of production and director of operations. Earlier in his career he was superintendent of General's East St. Louis, Ill., works and served at its Delaware works, Marcus Hook, Penn. Fox graduated from Yale University in 1926.

Schoch

Katz

Dr. Donald L. Katz, chairman of Chemical Engineering department of the University of Michigan will be the lecturer for the second **E. P. Schoch** Lecture Series at Batts Hall, The University of Texas, Austin. Dr. Katz, winner of the Hanlon Award and well known in the petroleum and chemistry industry, will lecture on "Phase Equilibria at Low and

SIEMENS



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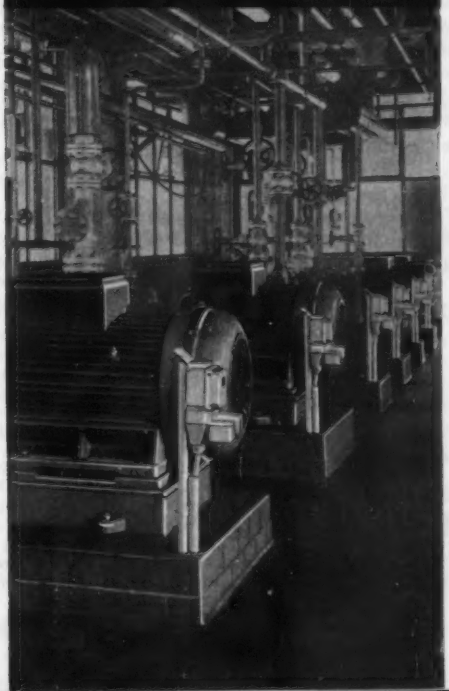

We supply

Flameproof
Motors and Switchgear

Complete
Electrical Installations

for all plants subject to explosion hazards

SIEMENS-SCHUCKERTWERKE AG

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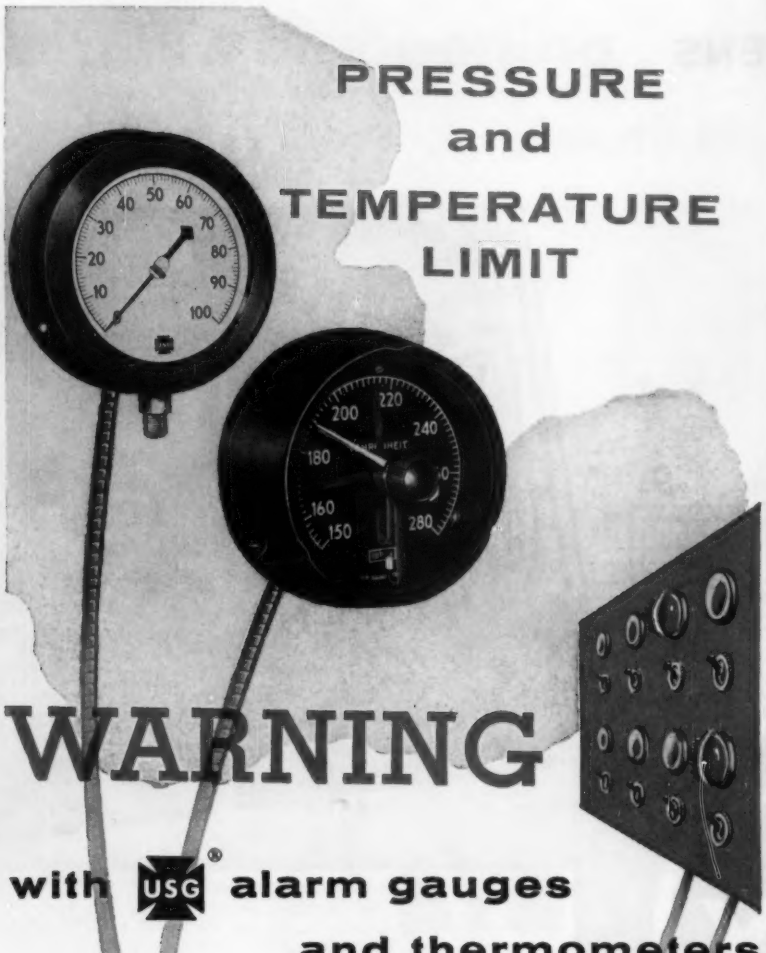

WARNING

with USG® alarm gauges and thermometers

These instruments provide a warning signal when temperature or pressure in a process rises or falls beyond predetermined danger limits.

Limit contacts are adjustable over the entire range with a "gap" as narrow as 2%. Suitable for lights, bells, buzzers or other signaling equipment requiring 0.1 amps or less. For larger alarm or relief devices, external relays can be furnished to increase rating to 6 amps.

Instruments may also be used as limit controls and as on-off controls when used in conjunction with lock-in relays and suitable delay tubes.

Available in cast iron or phenolic turret case in 12 pressure dial graduations from 0-30 lbs. to 0-10,000 lbs. Vacuum ranges 0-30". 5 compound dial graduations from 30"-30 lbs. to 30"-300 lbs. Thermometers available in all standard mercury, vapor and gas ranges with phenolic case only.

For complete details call your nearest USG distributor . . . see the "Yellow Pages" of your phone book . . . or write the factory for descriptive literature.

Get Your General Bulletin in the "Yellow Pages"

USG

UNITED STATES GAUGE

Division of American Machine and Metals, Inc.
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Home of the SUPERGAUGE®

MORE THAN 50,000 TYPES OF GAUGES • SUPERGAUGES • SOLID FRONT GAUGES • RECEIVER GAUGES • TEST GAUGES • RECORDERS • CONTROLLERS • TRANSMITTERS • PSYCHROMETERS • AVIATION INSTRUMENTS

Men in the Industry . . .

High Pressures." He will cover solid-liquid, vapor-solid, and vapod-liquid equilibrium as well as more complex systems. He will aim at the fundamental aspects as well as the practical ones.

The lectures will be held October 15 at 2 PM and October 16th at 2 and 8 PM. There will be no charge for the lectures. The lecture is not limited to the ex-students of the University of Texas. Anyone interested in phase equilibrium is invited.

A banquet will be held October 15, the eve of Dr. Schoch's 86th birthday.

The E. P. Schoch Lecture Series is made possible by voluntary contributions from his ex-students, friends and from many industries in Texas and surrounding states.

The E. P. Schoch Series started last October when Dr. W. K. Lewis presented the first lectures.

Robert A. Mitchell has been made chief engineer of the Midwest division of Blaw-Knox Co.'s Chemical Plants division, Pittsburgh. Mitchell graduated from the University of Alabama with a B.S. degree in chemical engineering in 1936 and acquired experience in chemical and petroleum plants operation with Kendall Refining Co., the Chemical Warfare Service and American Cyanamid Co. before joining Blaw-Knox in 1951. He has been associated with the Midwest headquarters since its formation in 1951. In his new position he will direct all engineering design and estimate work at the Chicago location.

Mitchell

A. E. Marshall, Jr. and **B. R. Starzanski** have been named assistant managers of the process promotion division of Socony Mobil Oil Co.'s manufacturing department in New York.

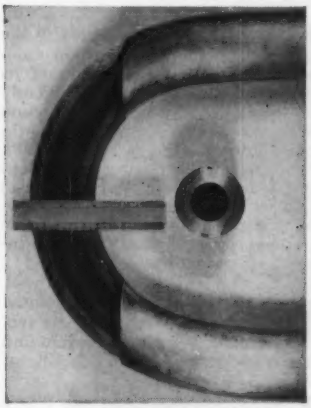
Both Marshall and Starzanski joined Socony Mobil in 1948 as members of the refinery engineering division. Marshall was a member of that division at the time of his appointment to his new post. Starzanski has worked for the process promotion division since November 1956.

Russell T. Branch, chairman of the board of Stone & Webster Engineering Corp., has retired after 45 years continuous service. He was elected chairman in May 1955.

Branch, during World War II, as executive vice president, was in charge of engineering and construction for Stone & Webster at the Manhattan Atomic Project, known as the Clinton Engineer Works in Oak Ridge, Tenn.

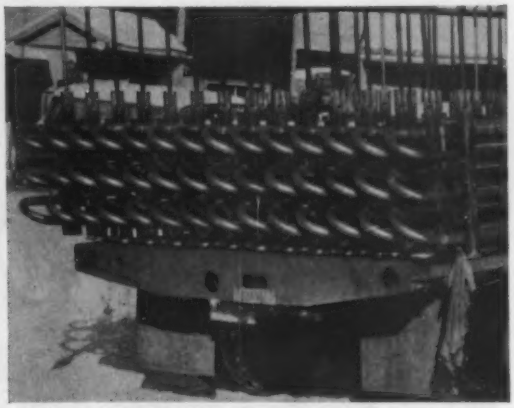
Upon his graduation from Stevens Institute of Technology in 1912, he joined the firm as a field engineer in Keokuk, Iowa, where Stone & Webster was engaged in construction work for the Mississippi River Power Co. As vice president and senior construction manager from 1933 to 1945 when he became president, Branch was in charge of the design and

BRIDGEPORT BRASS
COPPER ALLOY BULLETIN
CONDENSER AND HEAT EXCHANGER TUBE EDITION



Cutaway and end view of heavy wall duplex.

Welding bent tube ends on to straight tube lengths.



Assembled tube coils showing tube ends in place.

5,016 Feet of Heavy Wall Bridgeport Duplex Tube Provide Economical Answer to Unusual Pressure and Corrosion Problem

Unique Fabrication Methods Used to Bend 22-ft. Lengths to Small Radius

In building a new anhydrous ammonia plant for Northern Chemical Industries of Maine, the designer of the installation faced a number of important considerations in selecting the coils for the plant's primary and secondary condensers.

First, the condenser tubes had to be heavy enough to pass a hydrostatic test of 7500 psi. Second, unique fabricating requirements had to be met; tube ends had to be shaped into J-bends well under the usual minimum bend radius. Third, the "standard" problems of ammonia and sea-water corrosion had to be solved. Throughout, cost was a constant consideration.

Condenser Make-Up

The condensers themselves consist of one section with fourteen parallel banks of six passes each, and a section of fourteen parallel banks of ten passes each. Each section has an inlet and outlet header.

Bridgeport Duplex Chosen

Bridgeport Duplex Tube was selected, heavy steel inside to withstand pressure and resist ammonia corrosion, and .065" inhibited Admiralty cladding on the outside to combat sea-water corrosion. Stainless steel was considered, but because of its debatable service life *and* cost, was not chosen. The cost of Cupro-Nickel and Nickel-Copper Alloy was also too high. Admiralty-clad Duplex Tubes, on the other hand, have an estimated life of eight years—plus.

Precise Fabrication Problems

The near-mile of tube that went into both condenser coils was supplied in 22-foot lengths and was formed into finished coils by Portland Copper and Tank Works, Inc., So. Portland, Maine. One end of each tube had to be bent to a 4-7/16" radius, a job so precise that a special bending die was designed and built for the job.

Joining the bent tube lengths into finished coils involved stripping back the Admiralty cladding two inches from the end of each tube length. The exposed steel tube ends then were welded together and the weld surface ground smooth with the OD of the tube. Six-inch Admiralty sleeves were slipped into place and brazed in position. Special fabricating techniques were observed throughout every step of the operation.

Bridgeport for Precise Requirements

Bridgeport Duplex Tubes, of many varieties, have a long history of service and efficiency. As in this case, they are often the *economical* answer to a number of problems. Their wide use in ammonia refrigeration systems, ammonia and synthetic rubber production, the process industries, chemical plants, the petroleum industry and coke by-products plants is an "in-service" endorsement which can be applied to your own needs.

Bridgeport's experience with virtually every kind of corrosion and fabricating problem can serve you well. Put it to work for you. Call your nearest Bridgeport Office today.

BRIDGEPORT BRASS

Bridgeport Brass Company, Bridgeport 2, Connecticut • Offices in Principal Cities
In Canada: Noranda Copper and Brass Limited, Montreal

For more data on advertised products, use Readers' Service Cards, last page.

More than a mere pipe fitting!
catawissa
PERFECT SEAL
unions
give a 3 to 1
safety factor
PLUS
A PERFECT SEAL!
THERE'S A CATAWISSA PERFECT SEAL UNION FOR EVERY USE . . . ALL TEMPERATURES, ALL PRESSURES!
The full dependability of HOT FORGED STEEL is yours in a Catawissa Union (hot forged from solid steel bars) with several extra value features that are exclusive here at the UNION SPECIALISTS!
All Catawissa Unions are designed to give a 3-to-1 SAFETY FACTOR . . . 3,000-lb. service unions are tested to 9,000-lbs., 6,000-lb. service unions tested to 18,000-lbs., etc.
Exclusive Ball-to-Angle seat design assures a PERFECT SEAL even when the pipe is not in alignment!
Machining operations assure a UNIFORMITY AND ACCURACY heretofore found only in special fittings and, with rigid inspection both during and after machining, guarantees LEAKPROOF CONSTRUCTION!
Satisfaction is guaranteed in any application—whether it be general low pressure service or extremely high pressures and temperatures (for air, oil, gas, chemicals, hot oils, gases or steam).
WRITE FOR CATALOG 11
AVAILABLE FROM LEADING INDUSTRIAL SUPPLY FIRMS
CATAWISSA VALVE & FITTINGS COMPANY
25 MILL STREET ★ CATAWISSA, PENNA.

Men in the Industry . . .

construction of major projects in the U. S. and the Near East.

In 1952 he was granted an honorary degree of Doctor of Engineering from Stevens on the fortieth anniversary of his graduation. As a professional engineer Branch is licensed to practice in New York, New Jersey, Connecticut, Ohio, Tennessee, Georgia and Washington.

S. J. Jones, Jr., has been added to the executive staff of the Hydrocarbon Construction Co. with headquarters at its home office in Houston. Jones has recently resigned from the Graver Construction Co., where he was manager of the Southwest Construction division.

In his work for the Hydrocarbon Construction Co. he will have similar duties in connection with the construction of petroleum refineries, chemical plants, pipe line pump stations, in general all types of industrial process operations.

Kenneth H. Faulk has been appointed section leader of the special projects section of the Cities Service Research and development Co.'s process research laboratory at Lake Charles, La.

Among other duties, Faulk will supervise a newly-formed section to oversee projects formerly assigned to the fluidization and fluidized techniques section, in addition to project and economic evaluation work.

Harold R. Kemmerer, assistant manager of Shell Oil Co.'s manufacturing research department, has been named manager of the company's products application department.

Kemmerer succeeds **A. B. Culbertson,** who has retired after 33 years' service with the company. **J. D. Heldman,** special technologist in the manufacturing operations department, will replace Kemmerer.

Kemmerer graduated from Pennsylvania State University with a B.S. degree in chemistry. He joined Shell in 1935 as a junior mechanical engineer at the company's Wood River, Ill., refinery. He has served as chief research chemist and department manager at the Wood River refinery and research director at Shell's Houston refinery. He assumed his present duties in 1950.

Culbertson, a graduate of Missouri University, began his career with Shell in 1923 as assistant chief chemist at the company's Arkansas City, Kan., refinery. He was transferred in 1925 to the company's Norco, La., refinery as chief chemist and three years later became chief stillman. In 1930 he was named chief technologist at Norco, and was transferred to head office manufacturing in St. Louis in 1932. He became manager of the products application department in 1940. During World War II he served as assistant director of refining for the petroleum administration for war.

Claud B. Barrett, former vice president for The Texas Co. at Houston, has become senior vice president and chief executive officer at Houston.

Also elected senior vice presidents were:

Everett R. Filley, former vice president in charge of the Producing department-domestic, who becomes senior vice president in charge of Texaco's worldwide producing interests and activities.

Theodore A. Mangelsdorf, former vice

For more data on advertised products, use Readers' Service Cards, last page.

Mill scale removal by Dowell started this new plant off with a $100,000 operating profit

Here's how the management of a multi-million dollar corporation used its knowledge of chemical cleaning to start a new plant off in the right way—in the black.

Following construction, and before the plant was put on stream, Dowell was called in to remove mill scale from the following systems:

• Ammonia Compressors Suction and Discharge Piping • Engine Water-Cooling System • Engine Oil-Cooling System • Engine Jackets • Hydraulic Oil-Cooling System • Oxygen Suction and Discharge Piping • Miscellaneous Piping • Product Lines to Storage • Miscellaneous Towers

The total cost of this mill scaling was approximately $5,000. But, once in production, this plant did not have a single major shut down for maintenance caused by mill scale. The plant management credits Dowell Service with netting the plant an operating profit somewhere between 10 and 20 times the cost of the chemical cleaning. This amounted to between $50,000 and $100,000 the first year.

This particular case history is about a chemical company, but Dowell has startling performance data to show you—from your own industry. That's because chemical cleaning is so versatile. Dowell engineers are experts in removing scale and sludge from process systems, tanks and piping. They apply solvents in various ways—such as filling, jetting, cascading. Dowell furnishes all the necessary chemicals, trained personnel, pumping and control equipment.

For specific information on how chemical cleaning can help you to greater profits, call the Dowell office near you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

have Dowell clean it chemically DOWELL

A SUBSIDIARY OF THE DOW CHEMICAL COMPANY

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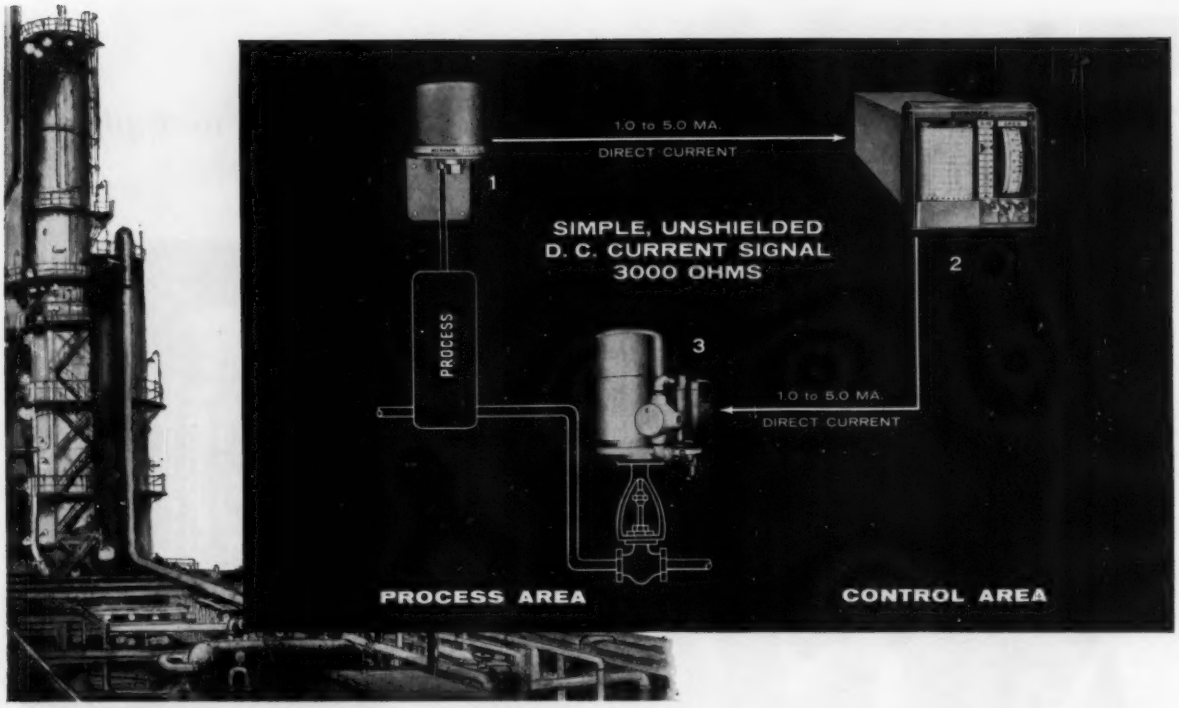


Let's look at a typical control loop of the 'American-Microsen' *ELECTRONIC PROCESS CONTROL SYSTEM*

This all-electronic dc system of miniature-type units assures the instrument engineer of 1) better control; 2) greater flexibility; 3) lower initial costs; 4) lower operating costs. The typical control loop above demonstrates the simplicity and functions of the system.

1. Transmitter. 'American-Microsen' transmitters are used for measuring pressure, temperature, differential pressure, liquid level, flow, and other process variables. The "Microsen" balance creates a stable dc signal for long distance transmission. Transmitters have no bearing pivots or linkages — assuring sensitivity and repeatability of measurement. Small size is made possible by printed circuitry and miniaturized components. The unit can be installed on meter piping, pipe pedestal or vertical surface.

2. Controller. A single unit combines all functions of measuring and recording or indicating the input signal; producing the control signal; and allowing manual-automatic process operation. Separate plug-in chassis provides the following functions: *A.* Records or indicates process variable. Strip or card chart recorder chassis available. *B.* Produces proportional, reset and rate control actions to regulate the variable. All control settings are calibrated. *C.* Permits switching to manual operation during start-up or emergency conditions, with true "bumpless" transfer from manual to automatic control.

Transistorized design increases reliability and service life. Miniaturization and consolidation of control functions reduces panel cost and wiring expense.

3. Electro-Hydraulic Control Valve Operator. A power unit with position feedback that operates slip-stem control valves. No compressed air is needed. Mountable on standard yokes supplied with conventional slip-stem control valves with bodies of single or double-seated construction, with V-port, parabolic, needle and equal percentage plugs, including valves of 4" stroke, and force available up to 3,250 lbs.

Where required, the American-Microsen Electro-Pneumatic Valve Positioner or the Electro-Pneumatic Transducer can be supplied.

In automating your processes for higher product quality and greater operating economy, you want the better control and simplified servicing provided by the American-Microsen Electronic Process Control System. We invite you to meet with one of our sales engineers to determine the best equipment for your service. Write for literature.

MANNING, MAXWELL & MOORE, INC.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

For more data on advertised products, use Readers' Service Cards, last page.

Men in the Industry...

president, becomes senior vice president in charge of the company's worldwide refining interests and activities.

James T. Wood, Jr., former vice president for the Company at Los Angeles, who becomes senior vice president and chief executive officer at Los Angeles.

New vice presidents are:

J. Howard Rambin, Jr., former assistant to the vice president in charge of the Producing department-domestic, who succeeds Filley as vice president in charge of that department.

J. B. Christian, former chairman of the board and managing director of Trinidad Oil Co., Ltd., a Texaco subsidiary, who becomes vice president in charge of Trinidad operations, with headquarters in New York.

L. C. Kemp, Jr., former general manager of Texaco's petrochemical department, who becomes vice president in charge of that department. Kemp will be responsible for the company's interests in the field of petrochemicals.

Jack Tielrooy has established consulting chemical engineering offices in Fullerton, Calif. Specializing in West Coast chemical industry, he will direct his main efforts to chemical plant feasibility studies and process design. Tielrooy was formerly vice president of Brea Chemicals, Inc. where he was in charge of Engineering and Commercial development. Prior to the formation of Brea in 1952, he was with Brea parent company, Union Oil Co. of California, and with Shell Chemical Corp. at various locations.

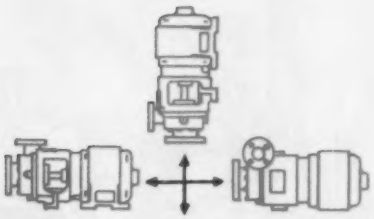
Tielrooy

Hubert H. Raborn has been elected secretary and treasurer of Kerr-McGee Oil Industries, Inc., Oklahoma City. He has been vice president and secretary of Triangle Refineries, Inc., Houston, a company recently acquired by Kerr-McGee. Raborn will continue in his position with Triangle.

Three men will serve as assistant secretaries and assistant treasurers of Kerr-McGee: **S. B. Robinson**, who has served as assistant secretary and assistant treasurer of the company since 1951; **W. O. Holdren**, formerly assistant secretary and assistant treasurer of the Deep Rock Oil Co., a subsidiary absorbed by Kerr-McGee in May, 1956; and **J. H. Lollar, Jr.**, formerly secretary and treasurer of Kerr-McGee, since July 1 treasurer of Triangle Refineries, Inc.

Humble Oil & Refining Company has announced the following additions to the staff of Technical Service division at its Baytown, Texas, refinery: C. A. Berghane, Jr., J. M. Bonem, E. A. Brigham, Jr., J. W. Cowand, Jr., J. R. Friday, R. O. Hall, P. W. Hawley, R. J. Klein, D. R. LeNoir, M. J. Lindsey, E. M. Mackert, G. L. Mueller, L. C. Murphree, Jr., J. C. Nichols, J. L. Pollak, Jr., R. J. Smouse, C. E. Stonerock, W. S. Vorhaben, G. C. Utz, and W. F. Wilhite.

Berghane, Nichols, Pollak, and Smouse



you get

versatility too

Plant engineers and operating personnel who have had experience with Ingersoll-Rand Motorpumps have found ease of installation of special importance and an extra advantage over and above Motorpump efficiency, dependability, stamina and low overall maintenance.

Motorpumps are compact to save space, they operate in any position, they present no alignment problem, need no baseplate or coupling.

These are important points to consider when you want a pump. See your local Ingersoll-Rand representative or write for the complete bulletin on Motorpumps.

Ingersoll-Rand

11 Broadway, New York 4, N.Y.

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MOTORPUMP sizes ¼ to 75 hp/capacities to 2800 gpm/heads to 650 ft

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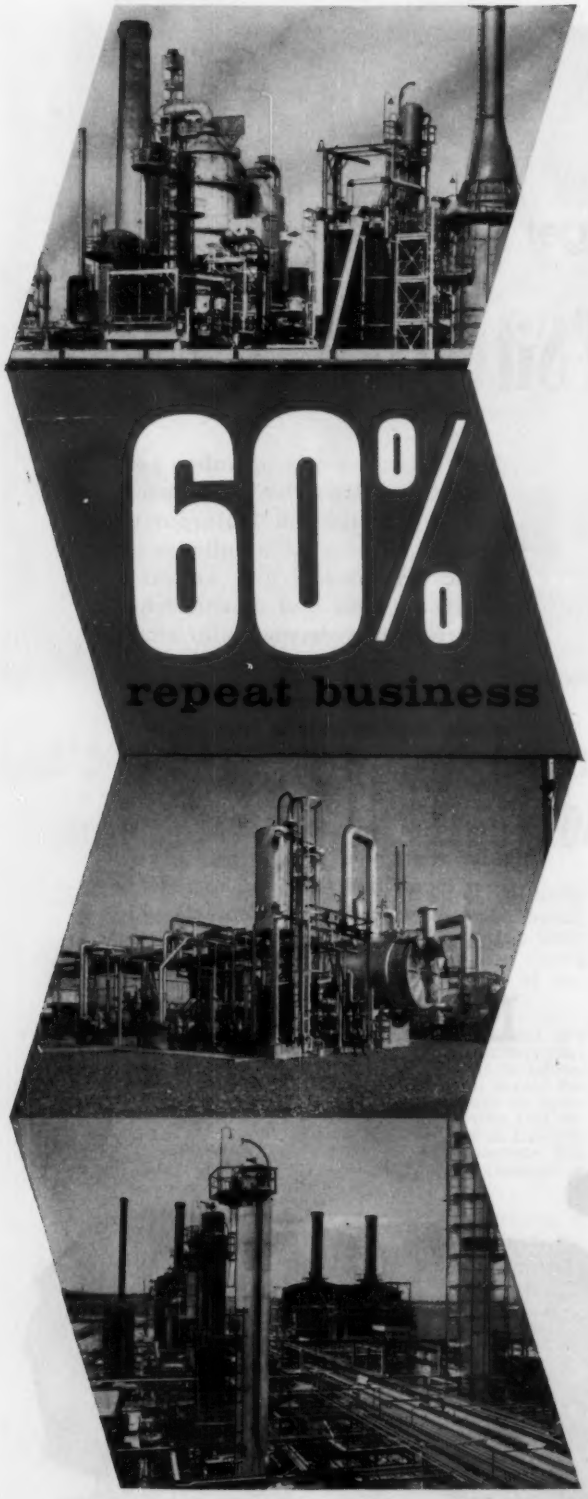

...proof of Parsons' performance!

60% of Parsons' contracts for the design and construction of hydrogen desulfurization, sulfur recovery and catalytic reforming facilities have been with previous customers. Proof positive of satisfactory performance.

PARSONS means progress

THE RALPH M. PARSONS COMPANY

ENGINEERS • CONSTRUCTORS

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JEDDAH
KARACHI
MADRID
NEW DELHI
PARIS
TORONTO

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Men in the Industry . . .

hold B.S. degrees in chemical engineering from Rice Institute; Bonem, from University of Colorado; Cowand, North Carolina State; Friday and Klein, Oklahoma State; Hall, Virginia Polytech; Hawley, LeNoir, and Utz, Texas University; Lindsey, Louisiana Polytech; Mackert and Mueller, Cornell University; Murphree, Georgia Tech; Stonerock, Purdue; Vorhaben, Tulane; and Wilhite, University of Florida. Brigham holds the B.S. and M.S. degrees in chemical engineering from Oklahoma State.

Argue

Ford

Fred W. Argue, vice president and engineering manager, and **Edward J. Ford,** vice president and senior construction manager, of Stone & Webster Engineering Corp. have been elected directors of the firm.

Argue, whose office is in Boston, joined Stone & Webster in 1941 as a power engineer. He became assistant engineering manager in 1952, engineering manager in 1954 and was elected a vice president in 1955.

Ford, whose office is in New York, joined Stone & Webster in 1923. In 1944 he was electrical superintendent on Stone & Webster work at the Oak Ridge atomic plant, and in 1945 was assistant superintendent on construction of a steam power station in Saudi Arabia. From 1948 to 1954 he was general superintendent for construction work on the Gulf States Utilities Co. properties in Texas and Louisiana. He was made senior construction manager in 1955 and elected a vice president in 1956.

John B. Godwin, Jr., Tulsa, B.S. chemical engineering, University of Tulsa (1957) has joined the technical services department of Monsanto Chemical Co.'s John F. Queeny plant at St. Louis.

Robert N. Pittilo, of Kirkcaldy, Scotland, B.S. chemistry, University of St. Andrews (1951), has joined Monsanto's Plastics Division, Springfield, Mass., as research chemist.

Ralph S. Jessup, a National Bureau of Standards authority in the field of heat standards, has been awarded the Department of Commerce Gold Medal for exceptional service, the Department's highest honor.

The award recognizes his "perfection of combustion calorimetry and development of the benzoic acid standard and the extension of precise laboratory techniques to measurements in difficult fields of fluorine reactions and solutions."

His work has included extensive research on standard sample materials for combustion, heat measurements on combustion of mixed hydrocarbon fuels and

NEW
DIAPHRAGM
PUMP*

PROVIDES PRECISION METERING AND PROPORTIONING OF FLUIDS

Versatile . . .
NEW high pressure range
NEW broad capacity range
NEW wide operating speed range

Cuts maintenance costs to a nub
NEW Teflon-faced diaphragm*
NEW packless design
NEW capsulated construction
NEW liquid end free of frictional parts
NEW lifelong lubrication

Accurate . . .
NEW precision for small quantities
NEW stepless stroke control

*Pat. appl. for

hills-mccanna company

THE PEOPLE WHO KNOW AND CONTROL FLOW

WRITE FOR FREE BOOKLET TO *REALLY* GET ACQUAINTED WITH THIS NEW DEVELOPMENT

Schematic drawing and full description shows you how the new McCannameter Diaphragm Pump works to deliver optimum performance in accuracy, versatility with low maintenance. Write for "A New Concept in Precision Metering and Proportioning of Fluids", booklet #301.

Hills-McCanna Company 2441 West Nelson Street, Chicago 18, Illinois

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MIN CHEMISTRY *at work*

case: how M & C materials and methods get the job done by sorption processing

Ad- or *ab-* . . . whichever prefix to sorption you prefer . . . M & C works with you to get the right balance of medium, efficiency, purity, treating conditions and economy.

Sorptive Mineral Report: M & C offers many grades for many jobs.

Molecules Out—you can refine, purify, decolorize; remove odors, colors, taste, moisture, acids, sulfur compounds, fluorides, unsaturates, many others.

Molecules In—other grades serve as carriers in scores of processes.

Anti-Caking—often 1% or less of specific sorptive grades make sticky, waxy, hygroscopic chemicals free flowing.

Drying—M & C desiccants dry air, hydrogen, CO_2, hydrocarbons, other fluids and gases.

Our business is to supply low-cost, nature-given materials that are *process-engineered* to make things go smooth in your plant . . . good in your markets. Use the coupon.

MINERALS & CHEMICALS CORPORATION OF AMERICA
3014 Essex Turnpike, Menlo Park, N.J.

I'm interested in a natural mineral product for_____

Send: ☐ Adsorbent Information ☐ Free samples

name_____ title_____

company_____

address_____

city_____ zone_____ state_____

For more data, see Chemical Materials Catalog Pages 330-334

MINERALS & CHEMICALS
CORPORATION OF AMERICA
3014 Essex Turnpike, Menlo Park, N.J.

Leaders in creative use of non-metallic minerals
ATTAPULGITE (*Attapulgus*)
ACTIVATED BAUXITE (*Porocel*)
KAOLIN (*Edgar • ASPs*)
LIMESTONE (*Chemstone*)
SPEEDI-DRI FLOOR ABSORBENTS

Men in the Industry . . .

reactions involving fluorine, measurements of heats of polymerization and thermodynamic properties of polymer solutions, and the design and construction of precise calorimetric apparatus.

Theodore E. Casselman, Jr., has been appointed chief chemical engineer of Stone & Webster Engineering Corp. He joined Stone & Webster in 1935 as a project engineer and was promoted a senior project engineer in 1953. He has been engaged in the design and engineering of various chemical, petroleum, gas and other industrial plants.

Casselman

Before joining Stone & Webster, Casselman worked as an engineer for Worthington Corp., Harrison, N. J.; Jackson Engineering Corp., Tulsa; and American Locomotive Co., New York. He attended Stevens Institute of Technology and received a B.S. degree in mechanical engineering from Massachusetts Institute of Technology in 1927.

Robert W. Hogeboom has been assigned to the position of assistant chief engineer of Spencer Chemical Co. In this capacity he will be working with the chief engineer on departmental activities which include new installations for the company as well as modifications of existing facilities.

Hogeboom joined Spencer in 1947 as a process engineer in the Development Department. In 1948 he was made a staff associate and the following year was promoted to staff member. In January, 1953, Hogeboom was assigned as a project engineer in the Engineering department and in 1954 became a senior project engineer.

He graduated from the University of Missouri with a B.S. degree in chemical engineering.

D. G. Schroeter, H. D. Holdridge, M. R. Haxton, and **W. F. Johnston,** in the Research and Development department of American Oil Co., Texas City, have been promoted.

Schroeter, who was named senior administrative supervisor, completed undergraduate study at the University of Cincinnati where he received a B.A. degree in chemistry in 1943. Schroeter received an M.S. degree in chemical engineering from Ohio State University in 1947.

Holdridge, who was promoted to administrative supervisor, joined American Oil in June, 1948, as a chemical engineer. After attending Southwestern University, he received a B.S. degree in Naval science and tactics from the University of Texas in 1947. He also received a B.S. degree in chemical engineering from that institution in 1948. While employed by American Oil he was granted a leave of absence to attend the University of Michigan where he received an M.S. degree in chemical engineering in 1952.

Haxton has been promoted to assistant patent advisor. He is a graduate of the University of Oklahoma where he received

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NO FOG *with Rochester*

Hermetically Sealed Dial Instruments

Moisture, when permitted inside an instrument dial, not only fogs the dial glass but has destructive access to vital working parts inside. In addition to hard-to-read instruments, it leads to undependable performance and shorter, costlier instrument life.

Rochester Manufacturing Company developed its own hermetic dial-sealing process to completely eliminate this moisture hazard. The RMC process insures that humid air will not be sealed in the instrument and locks moisture out *permanently*.

Look to RMC for Full-Line Instrumentation

LEVEL GAUGES

Illustrated is an 8" dial, float-operated level gauge, with magnetically driven pointer, for pressure vessels. What is your liquid level gauge problem?

PRESSURE GAUGES

Illustrated is a heavy-duty compound type gauge for service on high frequency, low amplitude vibration. What is your pressure or vacuum gauge problem?

TELL US YOUR REQUIREMENTS FOR DIRECT MOUNTING AND REMOTE INDICATING INSTRUMENTS, AND LET RMC ENGINEERING SKILL PROVIDE THE ANSWERS!

Write today, outlining your particular need or problem.

RMC

"You Can Rely On Rochester"

REPRESENTATIVES IN ALL PRINCIPAL CITIES

LIQUID LEVEL, TEMPERATURE and PRESSURE INSTRUMENTS

ROCHESTER MANUFACTURING CO., INC.

38 ROCKWOOD STREET • ROCHESTER 10, N.Y.

...and Around She Goes
"Where she stops —" only we know — and we do know. For over fourteen years we've been rating, testing and building Heliflow® Heat Exchangers for the sterling of American industry.
We offer you an accurately predicted performance with no guess work — and with Heliflow its performance is for certain.
Call on our local representative for your next heat exchanger problem and you too will be impressed by the advantages offered by Graham Heliflow Heat Exchangers.
Graham
GRAHAM MANUFACTURING CO., INC.
415 LEXINGTON AVENUE, NEW YORK 17, N. Y.
Offices in principal cities and Canada

Men in the Industry . . .

a B.S. degree in chemical engineering in 1951.

Johnston, who has been promoted to senior chemical engineer, will continue as a group leader in the Research and Development department. A native of Houston, Johnston received a B.S. degree in chemical engineering from Rice Institute in 1945, and was awarded an M.S. degree also from Rice in chemical engineering in 1947.

Rossow

Escherich

Dr. Alfred G. Rossow and **Fred A. Escherich** have joined the market research and analysis department of Socony Mobil Oil Co., Inc., to do research for the company's new petroleum chemicals department.

Dr. Alfred G. Rossow received his B.S. degree in chemistry from Georgia Tech in 1939, and his Ph.D. degree in organic chemistry from the University of Wisconsin in 1942.

He was with Monsanto Chemical Co. from 1942-54 and General Foods from 1954-57, doing research and development work for both companies.

Fred A. Escherich attended schools in New York and received his A.B. degree at Columbia in 1946. He then studied at New York University at night, receiving an M.S. degree in business administration in 1949.

Escherich was employed by American Cyanamid Co. at its Stamford research laboratories from 1946-53 and was with its market research department from 1953-56. He was with Pan American Chemicals Inc. from 1956-1957.

(It was reported by error in July PETROLEUM REFINER that these two gentlemen had gone to work for Monsanto Chemical Co.).

Arthur B. Kent has been named chief chemist at Sun Oil Co.'s Marcus Hook refinery. He succeeds **George E. Reese**, who has retired. Since January, Kent served as special assistant to **Walter C. Huffman**, superintendent of refining.

Kent joined Sun as a research and development laboratory technician in 1937, and was named a supervisor in 1943. He was in charge of the Podbielniak and crude oil testing laboratories in the company's Research and Development department from 1950 to 1957.

James N. Landis has been nominated for president of The American Society of Mechanical Engineers. He will be installed in office, after a letter ballot of the membership, during the ASME annual meeting to be held in New York in December, to serve for a term of one year.

Landis is vice president of Bechtel Corp., and a past chairman of both the San Fran-

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"It's like hearing a hundred taxi meters clicking away . . ."

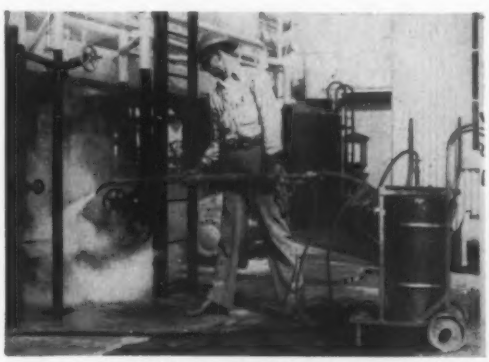
Don't sandblast—strip it! Powerful Oakite strippers, applied by hot flow-on, steam gun or cold-flow-on, safely float off paint, dirt, grease.

That's how one refinery man described his feelings about equipment downtime. And no wonder, with all those *bpd* being lost.

Oakite keeps your maintenance cleaning dollars from ticking away by holding downtime to an absolute minimum through the use of specialized materials, methods and equipment developed for the petroleum industry.

A valuable 48-page booklet "What Petroleum Men Should Know to Simplify Cleaning," explains the fast, easy Oakite way to clean towers, tanks, heat exchangers, drums, piping, tank cars, barges, salvaged equipment. Write today for a free copy. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

Don't rod out scale—dissolve it! Oakite chemical in-place cleaning lets you open up clogged piping without rodding or drilling . . . and no dismantling.



Don't scrape and brush—Oakite steam-gun it! "Mechanized" cleaning is exemplified by heavy-duty Oakite steam-detergent guns, including the sensational new "Hurriclean" that weighs only 6¼ lbs., is always cool to the touch, handles like a dream.

SPECIALIZED INDUSTRIAL CLEANING

OAKITE®

MATERIALS · METHODS · SERVICE

SCIENCE

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

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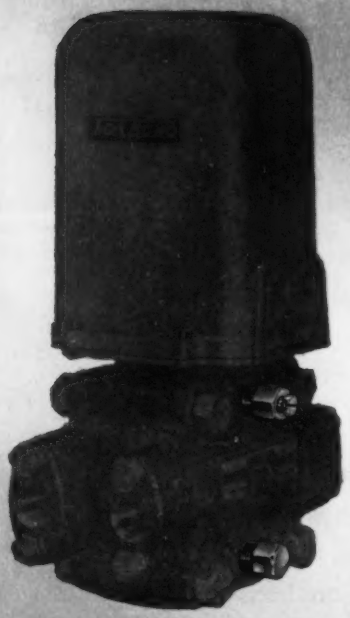
FOXBORO d/p CELL

unequaled –

Simplest installation — orifice flange tap connections at standard spacing, are provided at both ends.



Drain and vent holes at lowest and highest points on both sides.

Purged cover protects transmitter from weather, dust, and fumes.

Over 60,000 now in use!

No zero drift . . . positive overrange protection . . . high sustained accuracy even under the most punishing operating conditions. No wonder over 60,000 Foxboro d/p Cell Transmitters have been installed since they were introduced in 1948.

By introducing the modern concept of high speed flow measurement and control, these differential pressure transmitters have *revolutionized* many an industrial process. Bulletin 13-11A shows how — and portrays the benefits the d/p Cell Transmitter offers you. Write **The Foxboro Company, 749 Neponset Ave., Foxboro, Mass., U.S.A.**

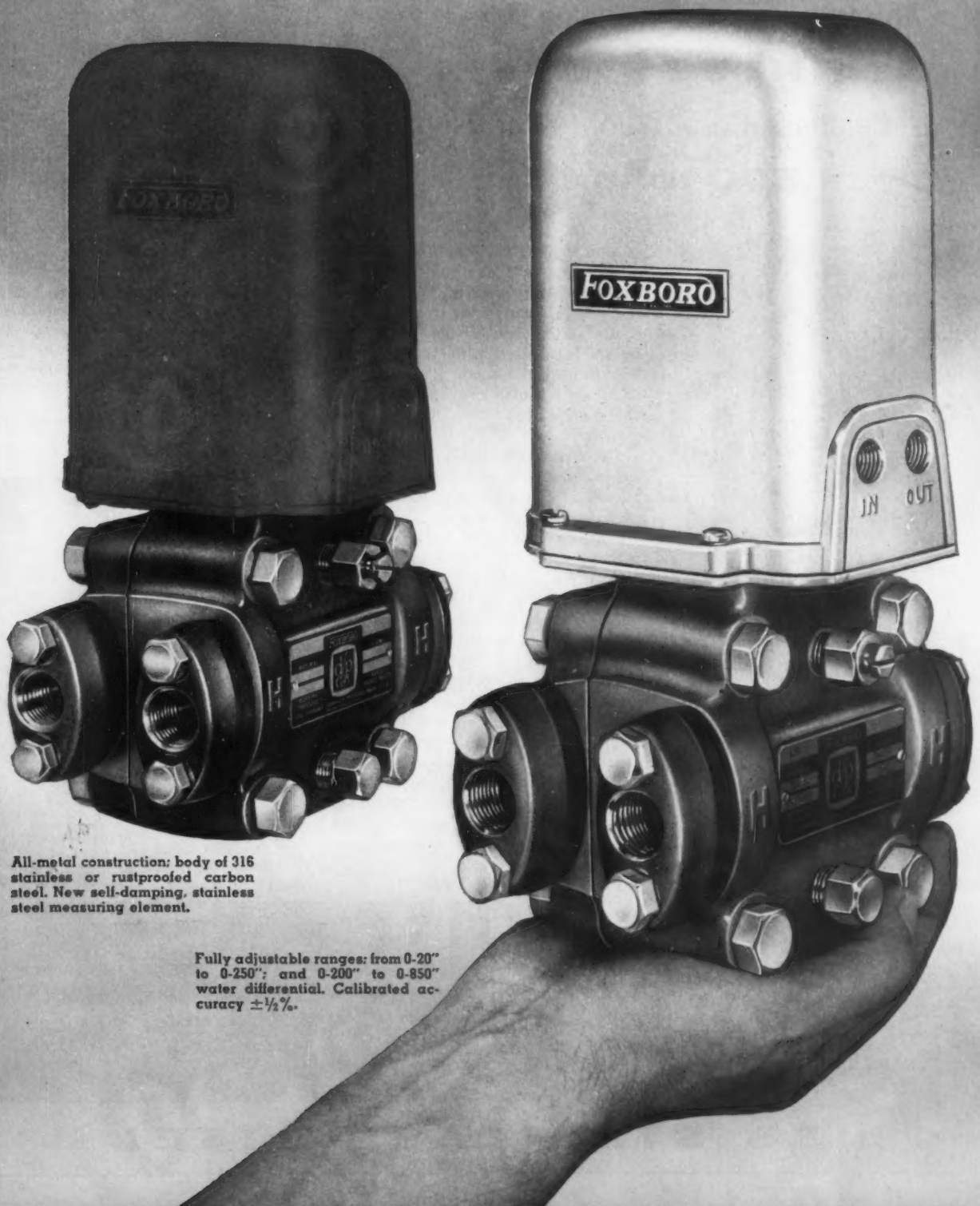
FOXBORO

REG. U.S. PAT. OFF.

FIRST in Flow Measurement and Control

FLOW TRANSMITTERS...

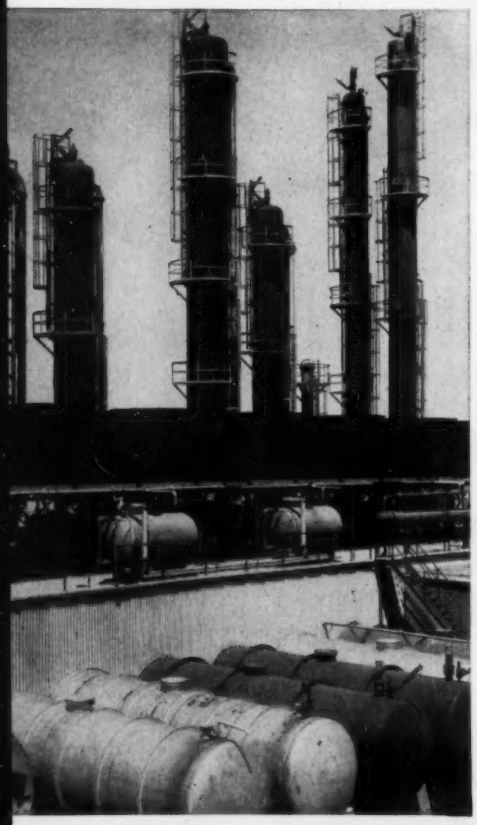
in accuracy, stability and performance



All-metal construction: body of 316 stainless or rustproofed carbon steel. New self-damping, stainless steel measuring element.

Fully adjustable ranges: from 0-20" to 0-250"; and 0-200" to 0-850" water differential. Calibrated accuracy ±½%.

Almost everything you see here is **STAINLESS STEEL** ... Celanese Corporation plant uses **1,300 tons** of it



CELANESE CORPORATION'S Pampa, Texas, plant was built in 1951. It produces acetic acid, acetic anhydride and related compounds by the air oxidation of liquefied butane. Briefly, the butane is oxidized in the reaction unit, transformed into acetic acid and other compounds which are fractionated in the purification unit, then further processed.

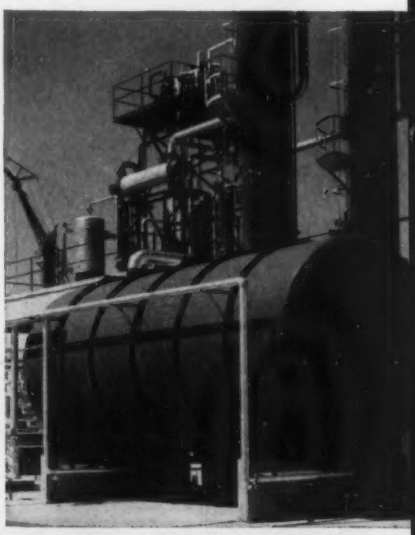
Throughout the entire process from the reaction units to the finishing operations, *Stainless Steel is used almost exclusively for process equipment and piping in contact with the product.*

Some 1,300 tons of Stainless were used in the original plant. Since then, expansion has added hundreds of additional tons. All the equipment is *solid* Stainless Steel, mostly Types 316 and 317 welded with Type 317 rod.

Management feels that Stainless Steel plays an important part in the smooth, efficient operation of this plant. Failures are few and predictable, in contrast to other materials that may fail disastrously and without warning.

Because of its reliability, Stainless was installed here *at the beginning*, and it has paid its own way, over and over again.

United States Steel Corporation, Pittsburgh
American Steel & Wire Division, Cleveland
Columbia-Geneva Steel Division, San Francisco
National Tube Division, Pittsburgh
Tennessee Coal & Iron Division, Fairfield, Ala.
United States Steel Supply Division, Warehouse Distributors
United States Steel Export Company, New York



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BILLETS • PIPE • TUBES
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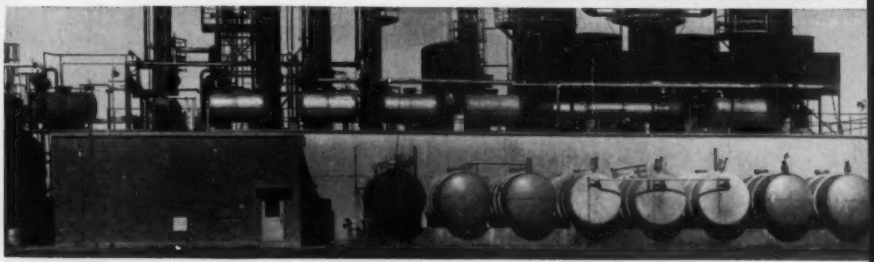

USS STAINLESS STEEL

UNITED STATES STEEL

Men in the Industry . . .

cisco section of ASME and of its Metropolitan section in New York.

Other nominations announced at the same time were to the posts of regional vice presidents and directors. Named were:

Charles E. Crede, vice president, Barry Controls, Inc., Watertown, Mass., vice president Region I.

Arthur W. Weber, vice president, Corning Glass Works, Corning, N. Y., vice president Region III.

Ernst W. Allardt, chief engineer, The Babcock & Wilcox Co., Tubular Products Div., Alliance, Ohio, vice president Region V.

Henry S. Aurand, Lieutenant General, U. S. Army, Ret., Honolulu, Territory of Hawaii, vice president Region VII.

L. N. Rowley, Jr., editor, "Power," McGraw-Hill Publishing Co., New York, N. Y., director-administrative activities.

Elmer O. Bergman, staff consultant, C. F. Braun & Co., Alhambra, Calif., director-codes & standards.

Ronald B. Smith, vice president, The M. W. Kellogg Co., New York, N. Y., director-technological activities.

Current president of ASME is **Dr. William F. Ryan,** vice president of Stone and Webster Engineering Corp., New York. He will serve until December when Landis will be installed.

Benjamin D. Russum has been named manager of the recently expanded and reorganized midwest headquarters, Chicago, of Blaw-Knox Co.'s Chemical Plants division. A native of Topeka, Kans., with a B.S. degree from Washburn College and an M.S. degree from Kansas State College. Russum has had extensive experience in serving process industries throughout the world. He joined Blaw-Knox in 1942 and has functioned as project manager in the design and construction of plants valued at over $300 million.

Russum

His most recent assignment has been as project manager on the engineering, procurement and construction of the first synthetic rubber plant in Great Britain. Prior to joining Blaw-Knox in 1942, Russum was associated with Kendall Refining Co. and Krebs Pigment and Color Corp.

Fred Wellmerling has been named advertising manager by Tidewater Oil Co. His headquarters will be in the company's home office in San Francisco.

L. D. Polderman has been appointed manager-engineering services, Technical Service department of Union Carbide Chemicals Co., division of Union Carbide Corp.

Polderman is an authority on the use of glycols and ethanolamines in gas treating operations and has published several papers on the subject. He joined Union Carbide following his graduation from Newark College of Engineering where he received a B.S. degree in chemical engi-

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PROCESS PUMPS

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COOLING SYSTEM

At the Brea Chemical Company in Southern California two 50 HP Verti-Line process pumps are handling 1800 GPM at 105°F, returning water from the ammonia synthesis area to cooling towers. *These units have been operating 24 hours a day since May, 1954 – without maintenance expense other than normal service.*

Over 100,000 satisfied vertical pump users agree there's no pump like Verti-Line for low first cost, economical operation, and negligible maintenance.

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For more data on advertised products, use Readers' Service Cards, last page.

Apart from a full line of Temperature CONTROLLERS

users have proved *these* instruments by WEST

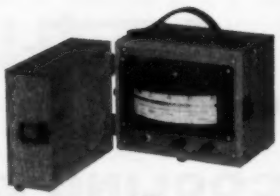
MODEL I SERIES

High Resistance indicating pyrometers

Complete Control Systems handily centralizing instruments

MODEL RT SERIES

Resistance Thermometer indicators (and controllers)



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Multi-Point indicators with TC switches

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Men in the Industry . . .

neering in 1936. He served as a sales engineer for Columbia activated carbon solvent recovery systems for ten years. In 1945 he was promoted to senior design engineer and was made supervising engineer in 1949 to head the gas treating chemicals customer service group, a position he held until his recent promotion.

Herbert A. McIntosh, a recent graduate of the Georgia Institute of Technology, has joined Texaco as a chemical engineer.

McIntosh received his B.S. degree in chemical engineering in June. He begins his professional career at Texaco's Research and Technical Laboratories at Port Arthur, Texas.

Worth

Mitchell

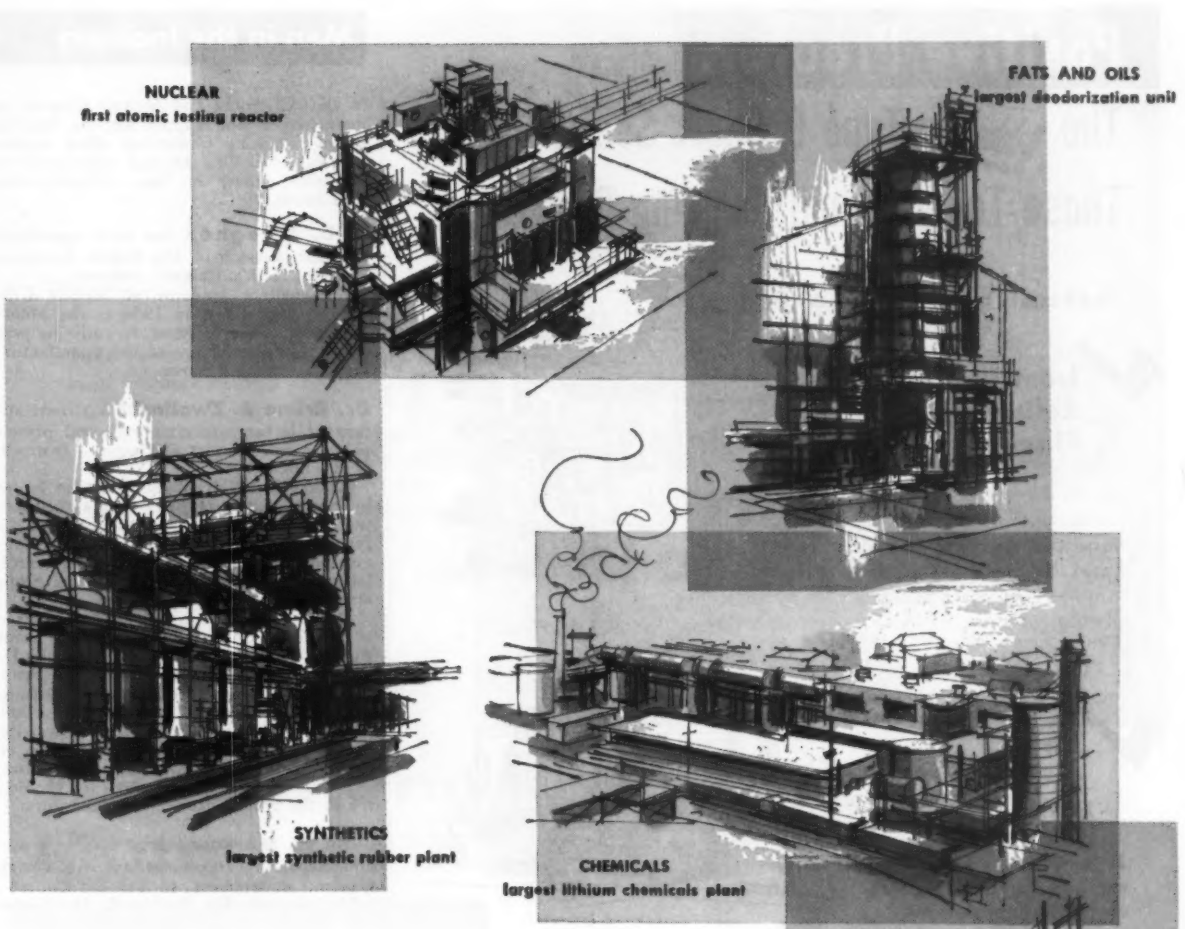
James H. Worth has been made assistant general manager of the Chemical division, Celanese Corp. of America. Prior to his new assignment, Worth served as director of the division's Technical and Economic Evaluation department.

Worth joined Celanese in 1953 as director of the Chemical division's Technical and Economic Evaluation department. He had previously been associated with the Monsanto Chemical Co. in engineering, product development and sales capacities. Worth is a graduate of Princeton University where he received a B.S. degree in engineering in 1940 and a chemical engineering degree the following year.

Robert L. Mitchell, former director of engineering research at the Chemical division's Research and Development Laboratories, Corpus Christi, Texas, succeeds Worth as the division's director of technical and economic evaluation. Joining Celanese in 1947 as a chemical engineer at the Corpus Christi laboratories, Mitchell served as a group leader and chief chemical engineer prior to his appointment as director of engineering research in 1955.

Mitchell graduated from Texas A & I College in 1943 with a B.S. degree in chemical engineering. After three years World War II duty as a radar-maintenance officer in the U. S. Navy, he entered Massachusetts Institute of Technology where he received his M.S. degree in chemical engineering in 1947.

David H. Bradford, Jr., sales manager of Mid-South Chemical Corp., has been elected vice president. Bradford has been sales manager of Mid-South since it was organized nine years ago. A chemical engineering graduate of Mississippi State College, he was in the Chemical Engineering Research department of Pure Oil Co. in Chicago for two years prior to World War II. During the war he was a major



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Regardless of the size or scope of your next project, the selection of the engineer-contractor remains a most critical decision. Pace setting projects provide one of the best proofs of the quality of creative resources and the extent of construction experience.

In offering a complete service that ranges from preliminary surveys, engineering and procurement to construction and initial operation, Blaw-Knox qualifications consistently meet the processing industry's most rigid requirements.

To see how this background can help your plans for process development, plant erection or modernization, contact our engineers for a preliminary discussion.

BLAW-KNOX

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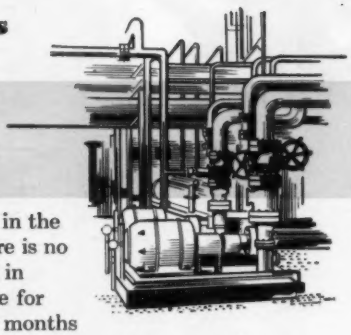
For more data on advertised products, use Readers' Service Cards, last page.

Positive Proof...

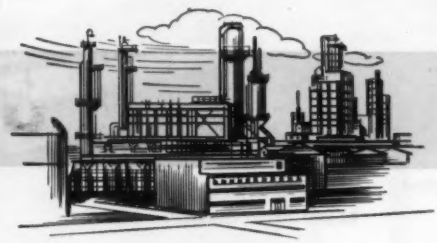
The John Crane® Type 9 Shaft Seal Solves Those Tough Liquid Handling Problems

Actual Field Reports



✓ from an Arkansas Refining Plant

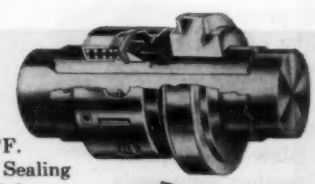
When it comes to avoiding trouble in the handling of naphtha at 420°F., there is no substitute for positive sealing. And in cases like this there is no substitute for "John Crane's" Type 9 Seal. Many months of completely satisfactory operation offers convincing proof.



✓ from a Louisiana Refinery

It takes a "lot of shaft seal" to handle a highly corrosive mixture such as an emulsion of sulphuric acid and butane. This stuff plays real havoc with metals due to its corrosive action. Despite this, Type 9 Seals on twenty seven pumps are pumping month after month in continuous service. At this same location, other Type 9's are effectively handling "fresh" sulphuric acid at the high suction pressure of 400 psi.

In cases like these . . . and in those confronting you . . . the surest answer is the "John Crane" Type 9 Seal.



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CRANE PACKING COMPANY

Men in the Industry...

in the Air Force and became director of maintenance and supply for the Eastern Flying Training Command. After rejoining Pure Oil Co., he was transferred to Memphis, where he was affiliated with Mid-South Oil Co.

R. D. Meagher has been appointed assistant manager of The British American Oil Co., Ltd.'s Calgary refinery.

Meagher, a graduate of McGill University, joined B-A in 1938 at the Montreal East refinery. Most recently he was head project engineer of the manufacturing engineering department.

Dr. Bruno J. Zwolinski has been appointed lecturer in chemistry and principal research chemist at Carnegie Institute of Technology.

At Carnegie, Dr. Zwolinski, who leaves his post as senior physicist at Stanford Research Institute, will serve as assistant director for two projects in the newly-created chemical and petroleum research laboratory dealing with data on the properties of chemical compounds.

Dr. Zwolinski received his B.S. degree at Canisus College, M.S. degree from Purdue University and his A.M. and Ph.D. degrees from Princeton University. Prior to joining the Stanford Research Institute in 1953 he served from 1948 as assistant professor of chemistry at the University of Utah. In 1955 he was given a leave of absence from the Stanford Research Institute to work with the program for chemistry in the National Science Foundation.

John E. Morrow, Jr., has been appointed special representative, industrial products department, of Sun Oil Co.

He succeeds **Dr. Archie B. Hoel** who has retired after 24 years with Sun.

Morrow joined Sun in 1948 as a research engineer in the technical service division of the research and development department at Marcus Hook refinery. In 1950 he was appointed section chief and in 1954 he became section chief of the products development division.

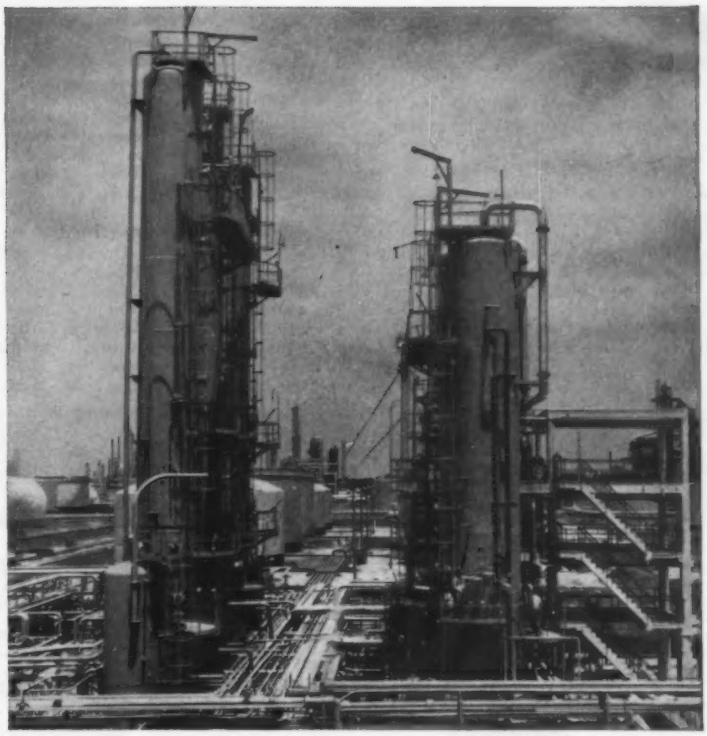
Morrow received a B.S. degree in chemical engineering and an M.S. degree in organic chemistry from the University of Illinois.

He is a member of the Society of Automotive Engineers and the AIChE.

Norman T. Robey was named assistant manager of the Whiting, Ind., refinery to succeed **C. H. Daugherty** who retired from Standard Oil Co. (Indiana) last month. **Delmer G. Debo,** formerly superintendent of the mechanical division at Whiting, succeeds Robey as assistant manager of the Casper, Wyo., refinery.

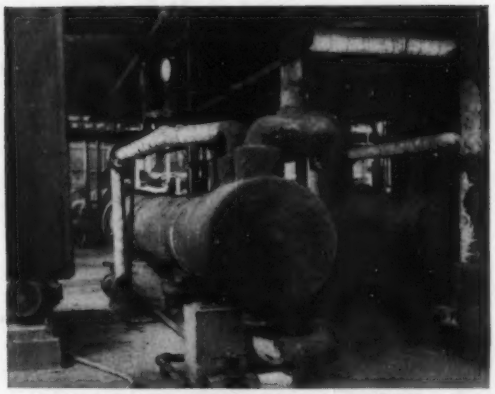
In the company's general office at Chicago, **Robert S. McDaniel** returned from special assignment to his former position as supervisor, light oils planning, and **F. Curtis Smith** was named supervisor, capital expenditures—miscellaneous contracts planning, in the planning division. **Richard H. Dust, Jr.,** was named assistant supervisor, cost, operations division.

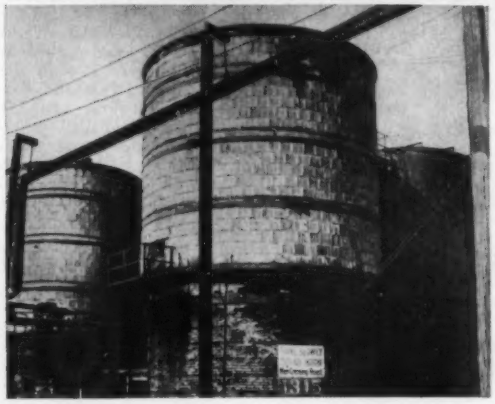
G. Victor Hopkins has been appointed assistant director of personnel of Arthur G. McKee & Co., Cleveland. Hopkins is a native of Baltimore, Md., where he received his education and early industrial experience as personnel manager for the Baltimore Salesbook Co. for nine years. In 1949 he became associated with the Bell



Take towers — This one is saving a large southern refinery $20,000 a year in maintenance costs. Solid 7/16-in. Monel* nickel-copper alloy walls save the caustic stripping tower in the refinery's Unisol unit from the corrosive bite of 47° Baume caustic at 290° to 300°.

Experience spurs use of Monel for handling caustics





Heat exchangers (left) — Here's a preheater that is exposed to contaminated caustic entering the regenerator tower and to pure caustic leaving. Despite severe conditions, the preheater is giving trouble-free service. Shell and tubes are Monel alloy.

Agitators (lower left) — In this large agitator tank at an eastern refinery, bottoms and sides up to 6 ft. were replaced with Monel alloy. A wise choice. Monel alloy has proved to be the most economical material to use for this service.

Experience like this has led to the use of Monel alloy for a variety of other caustic processing units: reboiler tube bundles, hot caustic lines and caustic storage vessels, to name a few. In petrochemical plants using caustics, Monel alloy guards product purity.

Making available field experience in overcoming caustic corrosion is one of Inco's many services. Why not take advantage of this service? Send us details of your problem and our Research and Development Engineers will work with you to provide a solution.

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INCO TRADE MARK **Nickel Alloys**

Monel... *for minimum maintenance*

Men in the Industry . . .

Vocational Service in Cleveland as an employment counselor and later as manager.

J. W. "Win" Miller has been named assistant to the president of Union Oil Co. He will headquarter in San Francisco where he will represent the president in the company's Bay Area activities.

Previously Miller was executive vice president of Brea Chemicals, Inc., a wholly owned Union Oil subsidiary. He joined Union Oil in 1936 at San Francisco as a contractor representative.

Joseph W. Meehan has been elected vice president with responsibilitiy for transportation and crude oil supply of Derby Refining Co.

Meehan, 48, has for 25 years been associated with The Pure Oil Co., Chicago, most recently as general manager of its Crude Oil Purchasing division, and as president of Pure Transportation Co. and president of Arapahoe Pipe Line Co.

George J. Petterschmidt has retired as president of El Dorado Refining Co., El Dorado, Kan. He had been with the company since 1923, and is succeeded by **Sam L. Roberson.** Other changes include appointments of **Harold J. Datin** to vice president, manufacturing, and **Lawrence G. McKinney,** to treasurer.

J. A. Vickers, president of The Vickers Petroleum Co., Inc., has been elected chairman of the Governor's Oil Advisory Committee at the group's initial organizational meeting, June 17.

Members of the committee, appointed by Governor George Docking, include: **Robert L. Williams,** Imperial Petroleum Co., Wichita; **Oliver Brown,** Liberal; **Harold Wansley,** Hutchinson; **Chris Scheedy, Jr.,** Yates Center; **George Peterschmidt,** El Dorado Refining Co., El Dorado; **Charles Byers,** Great Bend, Kan.; **Thomas H. Allan,** Wichita; **Glenn Dunne, Sr.,** Wichita; and **Jerry Driscoll,** Russell, Kan.

The Governor's Oil Advisory Committee will investigate all operational problems affecting the oil industry in Kansas and represent the oil industry in Kansas by making recommendations on the solving of these problems to Governor Docking.

Oscar B. Schier, II, has been designated secretary-elect of The American Society of Mechanical Engineers by unanimous vote of the Society's council.

He will succeed **Clarence E. Davies** who will retire as secretary after 23 years of service.

Schier has been a member of the society since 1932, and a member of the staff in various capacities for the past 11 years. He was elected assistant secretary in 1953 and advanced to deputy secretary last December.

He was graduated from Lehigh University in 1929 with the degree in mechanical engineering and received his M.A. degree from the same Institution the following year.

He was formerly associated with the Consolidated Edison Company of New York.

Andrew J. Foglia, Frederick C. Foster and **Roger M. Weil** have joined the staff of W. R. Grace & Co.'s Polymer Chemicals division, Clifton, N. J., where they will be assigned to polymer research and development.

Dr. Andrew J. Foglia received his Ph.D. degree in physical chemistry from the Polytechnic Institute of Brooklyn in 1951. For the past six years, he has been assistant to the director of the Surgical Products division of American Cyanamid Co., Danbury, Conn.

Dr. Frederick C. Foster received his Ph.D. degree in 1946 from Columbia University. For the past eleven years, he has been a senior research chemist with Firestone Tire & Rubber Co., Akron, Ohio, where he has been concerned with the structure of polymers.

Dr. Roger M. Weil attended the Swiss Federal Institute of Technology, Zurich, and received his Ph.D. degree from the University of Geneva in 1951. Dr. Weil's first position in the United States was as a member of a consulting team with the late Professor Dr. Kurt Stern and Dr. Herman F. Mark at Polytechnic Institute of Brooklyn. He has been engaged in research on titanium derivatives and polymer chemistry for the past four years.

Richard T. Kropf, vice president and director of research for Belding Heminway Co., Inc. was elected president of American Society for Testing Materials at its annual meeting in Atlantic City last month. **F. L. LaQue** of International Nickel Co. Inc. was named vice president for the two-year term and **A. E. Juve,** of The B. F. Goodrich Co., director for three years.

Kropf, a native of Chicago, also directs

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ONLY 4 STANDARD AND 3 REGULAR Desco Lubricants handle ALL valve services, and most plants require only one or two. Reduce the chance of using the wrong lubricant. Eliminate large warehouse stocks. Specify DESCO.

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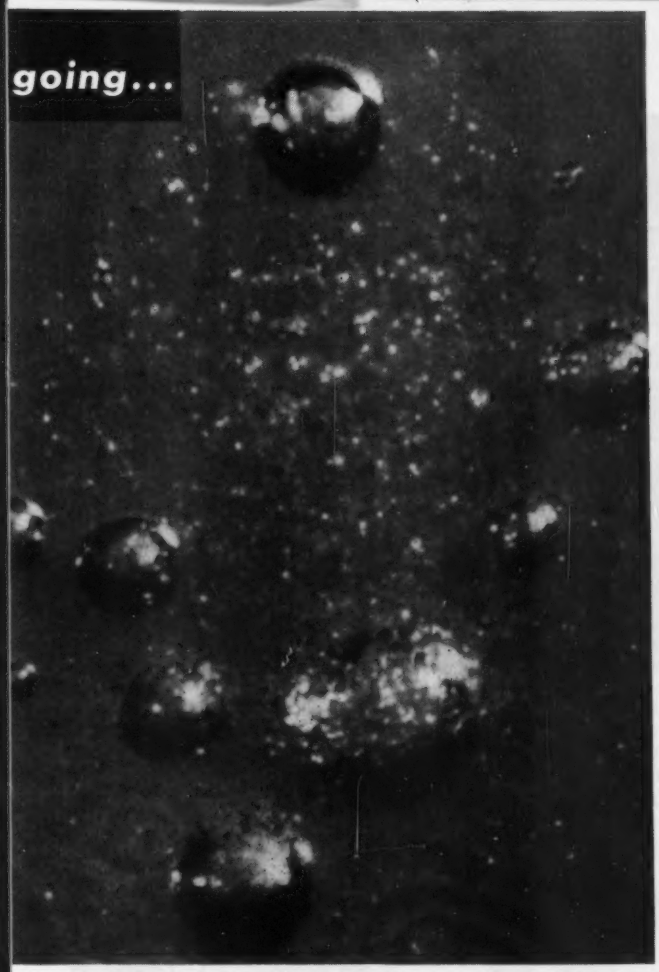

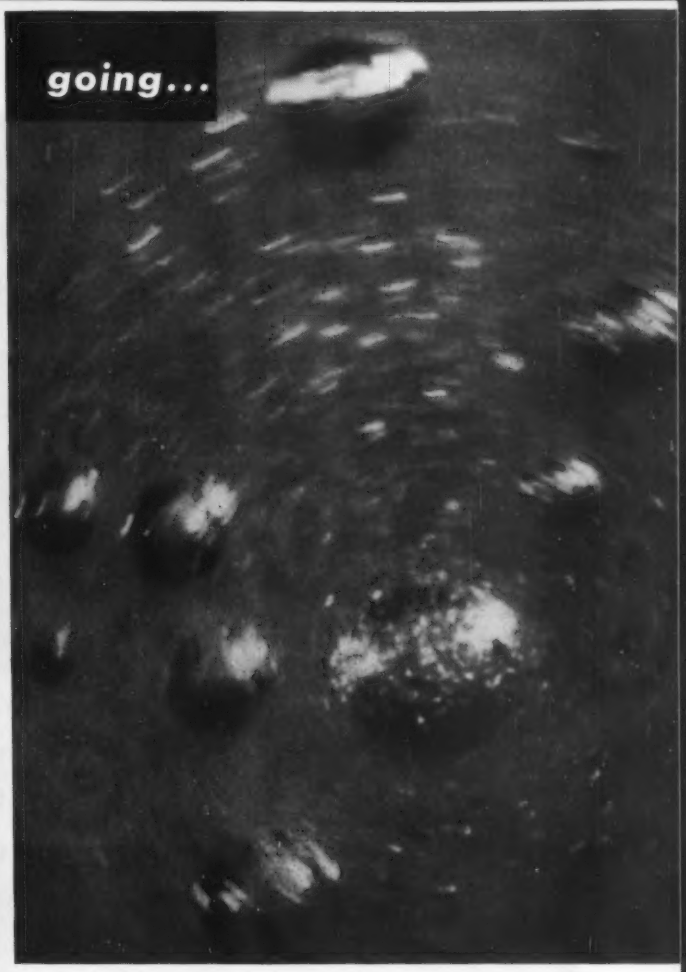

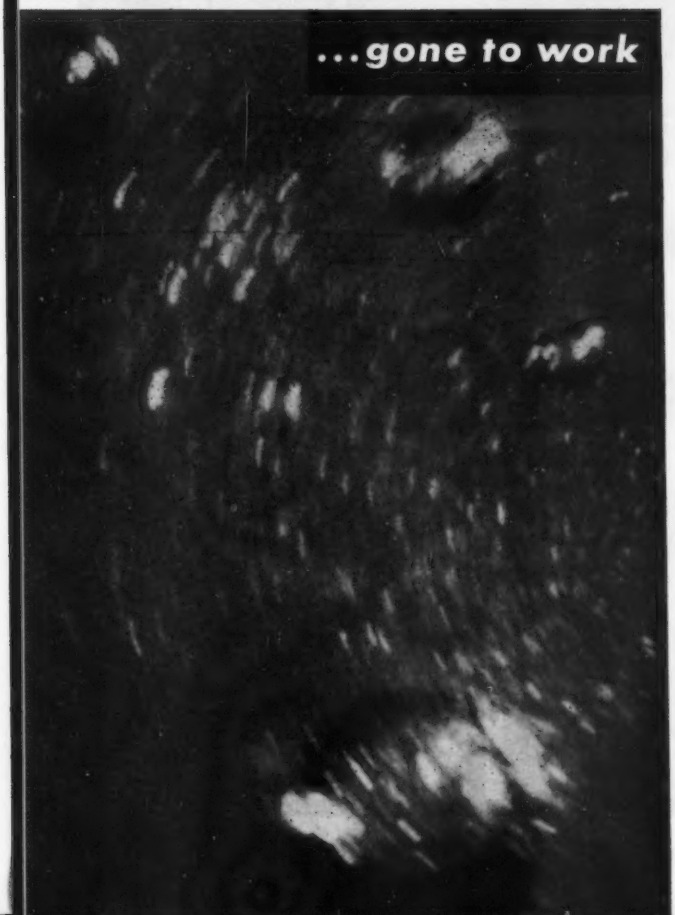

Why refineries everywhere are giving DALPAC* a whirl

These dramatic microphotographs show how a single flake of Dalpac 4 antioxidant is speedily dissolved into the gasoline stream.

Produced by Hercules from its own basic source of pine chemicals, Dalpac 4 effectively inhibits gum formation, maintains engine cleanliness, and stabilizes gasoline color. A major advantage is that Dalpac will not form deposits in fuel intake systems.

Dalpac 4 type inhibitor meets military specifications for aviation gasoline and jet fuel. It prevents decomposition and sludging in turbine oils. It retards sludge and peroxide formation in transformer oils without changing their electrical properties.

You will find Dalpac 4 also effective in petroleum waxes, brake fluids, hydraulic oils, slushing oils, cutting oils—almost any petroleum product where resistance to oxidation is desired.

Dalpac 4 is shipped from Gibbstown, New Jersey and Hattiesburg, Mississippi, and is available in solid and liquid forms. This antioxidant is made from Hercules' own basic source, para-cresol. Buying Dalpac 4 from Hercules is your assurance of both supply and top quality. **Hercules Trademark*

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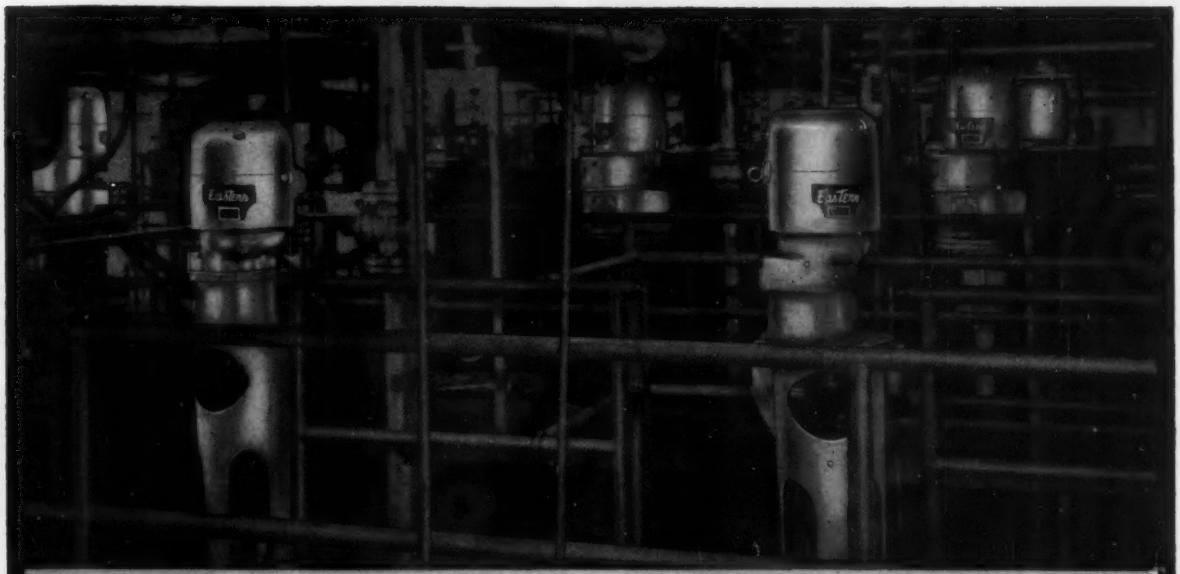
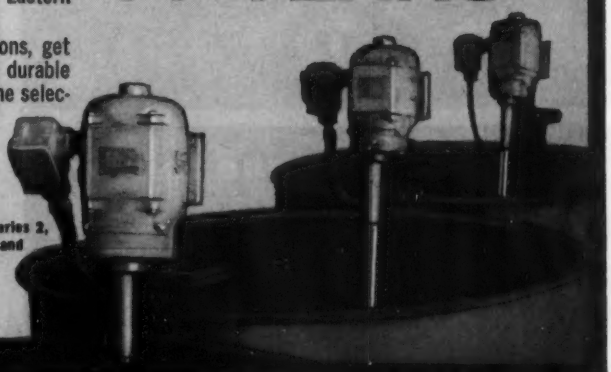


Back in 1942 the new synthetic rubber program was of urgent importance to the war effort. Naugatuck Chemical Co., now a Division of U.S. Rubber Co., developed processes that included fluid mixing applications. Many of Naugatuck's top-entering and portable mixers were engineered and manufactured by Eastern Industries specifically for these processes.

After fourteen years of hard, continuous service, these Eastern Mixers continue proving their built-in **reliability.**

If you have a process entailing critical operating conditions, get a long-term guarantee on your investment by selecting durable Eastern Mixers. Eastern offers engineering assistance in the selection of proper mixers from the complete Eastern line.

CONTINUOUS SERVICE . . . 14 YEARS



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INDUSTRIES, INC.
Mixer Division
Regent Street
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Write for Catalog Series 2, containing product and engineering data.

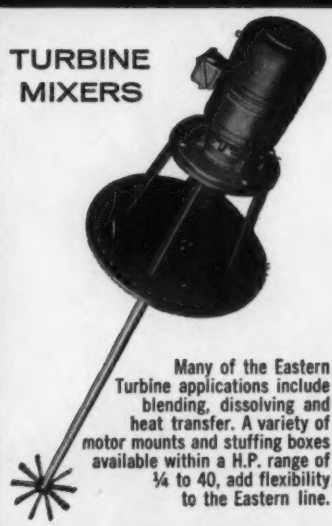
PORTABLE MIXERS

Various models offer a choice of speeds and H.P. dependent upon the consistencies of fluids. All models are available with shafts and propellers of various alloys. Single and dual propellers, and a wide choice of motors give flexibility to handle the most critical of operating conditions.

TOP & SIDE ENTERING MIXERS

Heavy-duty models cover the range from ¼ to 30 H.P., at speeds from 280 to 1725 R.P.M. Versatile in design . . . rugged in performance, these mixers offer a wide choice in mounting arrangements and motors. All side entering models are available with stuffing boxes which can be repacked with a full tank.

TURBINE MIXERS



Many of the Eastern Turbine applications include blending, dissolving and heat transfer. A variety of motor mounts and stuffing boxes available within a H.P. range of ¼ to 40, add flexibility to the Eastern line.

Men in the Industry . . .

the activities of the Industrial Thread division and serves as vice president and general manager of Belding Corticelli Industries, Inc. He is a 1931 graduate from M.I.T. and has been with Belding since his college days. A member of several professional societies, he has served on many committees particularly for ASTM.

LaQue, vice president and manager of the Development and Research division of Inco, is a native of Canada who got his degree of B.S. in chemical and metallurgical engineering from Queen's University, Kingston, Ont. He joined Inco in 1927 and since then has devoted his activities to the field of corrosion and corrosion-resisting materials. It was under his leadership that Inco's well-known corrosion testing stations at Kure Beach and Harbor Island, N.C. were established. A member of ASTM since 1935, he has been the recipient of many professional honors.

Juve has been employed by Goodrich since receiving his bachelor of C.E. from Ohio State in 1925. Presently he is director of technical research for Goodrich at Brecksville, Ohio.

G. H. Herridge has been named managing director and **H. W. Fisher** appointed as an executive director of Iraq Petroleum Co. with the title of "joint managing director" of the Iraq, Basrah and Mosul Petroleum Companies. **Sir Stephen Gibson** retired on June 30 as managing director after serving in that capacity for seven and a half years.

Herridge joined Iraq's predecessor, Turkish Petroleum Co. in 1926, having gone to Bagdad before oil in commercial quantities had been discovered. In April, 1943 he was appointed assistant general manager of the company's operations in the Middle East. He has been in London headquarters since 1951, holding the title of an executive director since 1953.

Fisher, a 1927 M.I.T. graduate, in 1945 became a director of Esso Standard Oil Co. and president of Enjay Co., Inc. In 1951 he became co-ordinator of refining for Jersey Standard's worldwide refinery operations. Since 1954 he has been in London as Jersey's shareholders representative in the U.K. and chairman of its co-ordination committee for Europe.

Deaths

Colonel George A. Burrell died in New York City after a long illness. He received his B.S. degree in chemical engineering from Ohio State University, and in 1934 was awarded the Hanlon Award from the Natural Gasoline Association of America. In 1952, he became chairman of Burrell Corp., Pittsburgh, Pa.

George Granger Brown, 60, dean of The University of Michigan College of Engineering since 1951, died at 6 p.m. Monday, Aug. 26, at University Hospital. Dean Brown was known internationally for his research and contributions to engineering education. In 1954 he was named to deliver the 30th Annual Henry Russel Lecture, regarded as the University's highest professional recognition of academic and scientific competence. He received the NGAA Hanlon Award in 1940, and was president of the American Institute of Chemical Engineers in 1944.

another installation of heat exchangers by National-U.S.

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HT-1.

Heat Exchangers by National-U. S. at Great Lakes Steel Corporation, Detroit, Michigan.

For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

Balhouse

Harold J. Balhouse has been appointed manager of the newly-formed Nuclear division of Alby Steel Products Co., Linden, N. J.

Balhouse has been manager of Special Products Engineering for Walworth Co. where he was responsible for new product development and all activities relating to manufacture of valves for radioactive nuclear services. Prior to joining Walworth in 1951 he spent three years with Knolls Atomic Power Laboratory where he developed prototype liquid metal valves for the power plant of the atomic submarine "Seawolf."

He is a graduate of Illinois Institute of Technology and the General Electric Co. Advanced Creative Engineering Program.

Anderson

A. G. Anderson has been named district manager of the Southern territory for The Pfaudler Co., Rochester, N. Y. Anderson has been with Pfaudler since 1936 when he joined the Elyria, Ohio, plant staff. He worked in New York, Chicago and Dallas offices before moving to Houston in 1953 to cover the territory of Louisiana and eastern Texas as sales representative. He studied at the University of Florida and Kenyon College.

Nichols

N. B. Nichols, a former director of research for Taylor Instrument Companies has rejoined the organization after an absence of several years to become chief engineer. He succeeds **Ralph E. Clarridge**, who has been appointed to the president's staff as specialist for new product lines.

Nichols left Rochester to become professor of eletctrical engineering at the University of Minnesota. He subsequently joined the Raytheon Manufacturing Co. of Waltham, Mass., as assistant vice president and manager of commercial engineering.

Meginnis

Charles E. Meginnis has been promoted to sales manager for industrial chemicals of Davison Chemical Co. Division of W. R. Grace & Co. He has been assistant sales manager, and his new post and other appointments follow assignment of **Lewis C. Reid**, formerly sales manager, to other responsibilities in the company as part of an expansion program in new fields.

H. H. Wilson, formerly sales control manager, has been made assistant to Meginnis.

Gurley

Sam Gurley, Jr., has been appointed vice president of sales for Olin Aluminum. He had been vice president-sales of H. K. Porter, Co., Inc.

Gurley, to be responsible for Olin Aluminum's sales, advertising and promotional activities, had been with H. K. Porter Co., Inc., Pittsburgh, since October, 1956. In addition to serving as vice president-sales for the corporation, he was also vice president and general manager of the Refractory division, and an officer and director of six other divisions of the company.

Robert M. Ward, former division manager for Thompson Products, Inc., has been selected as manager of the Berkeley division of Beckman Instruments, Inc.

Ward joins Beckman following a 16-year association with Thompson Products, the last four as division manager. He also served as sales manager for the company's Special Products Division in Cleveland, eastern sales representative, sales engineer and as product engineer.

During World War II, Ward was an aircraft engineering officer in the U. S. Navy. He received his degree in mechanical engineering at Case Institute of Technology in Cleveland and studied aeronautical engineering at the University of Minnesota. He is a member of the Society of Automotive Engineers.

Ward

John F. Reed has been appointed general manager of the Consolidated Ashcroft Hancock division of Manning, Maxwell & Moore, Inc. Reed joined the company in 1944 as a planning engineer. A graduate of the Missouri School of Mines, he was previously with U. S. Steel and the McDonnell Aircraft Corp. Before his new appointment, Reed was works manager of the Muskegon, Mich., plant.

Reed

Charles G. Strowe has been promoted to manager of the central district of Blaw-Knox Co.'s Chemical Plants division. Since 1954, Strowe had been assigned to the central district as district engineer. He attended Carnegie Institute of Technology, and has been with the Chemical Plants division of Blaw-Knox since its inception in 1941, except for a brief association with the United States Rubber Co. He has served as a design engineer and project engineer in the engineering and construction of plants for the synthetic rubber, atomic energy, petroleum, and chemical industries.

Strowe

Robert L. Rice has been promoted to general sales manager of Fischer & Porter Co. Rice joined F&P in 1950 as a sales engineer, becoming sales manager of the Cincinnati office a year later. For the past three years he has been manager of F&P's Water and Waste division, **James Haskett** replaces Rice as manager of the division.

Rice graduated from the University of Cincinnati with a B.S. degree in mechanical engineering. He is a member of Tau Beta Pi and Pi Tau Sigma fraternities, and numerous technical societies.

Rice

Robert F. Lay has been promoted to vice president and assistant general manager of The Cooper-Bessemer Corp., Mount Vernon, Ohio.

In his new capacity Lay will be directly responsible for coordinating the operating groups of the company. Lay joined Cooper-Bessemer in 1924 while a co-op student at the University of Cincinnati, after which he became associated with the Baldwin Locomotive Co. as assistant sales manager. He then joined the Elliott Co.,

Lay

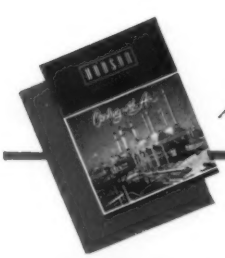
Cooling with Air AND MINIMUM WATER IN A MODERN REFINERY

Process cooling in Cosden Petroleum Corporation's new West Texas refining units is largely by direct use of air. Over 250 million BTU's per hour are dissipated directly to five billion standard cubic feet per day of air moved by 38 fans in HUDSON Solo-aire or Combin-aire units.

Solo-aire units are used where low effluent temperatures are unnecessary. Combin-aire units, in which air is first precooled with water, are used where lower effluent stream temperatures are required. The cooled water from the Combin-aires is available for other cooling services; the Combin-aires in this case performing the further function of water cooling towers. Water spray, carryover or condensation is impossible as the effluent hot air is under saturated with water vapor. Combin-aires are installed adjacent to other process equipment.

These Solo-aires and Combin-aires at Cosden, and hundreds of other HUDSON units in oil, gas and chemical processing plants confirm the advantages of cooling with maximum air and minimum water.

Before finalizing design of new process units, let HUDSON assist you in determining optimum balance in use of air and water.



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How ANHUESER-BUSCH, Inc. handles waste materials efficiently and maintains plant-wide cleanliness

THE DEMPSTER DUMPSTER® SYSTEM

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ELI LILLY AND CO.
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ARMOUR AND COMPANY
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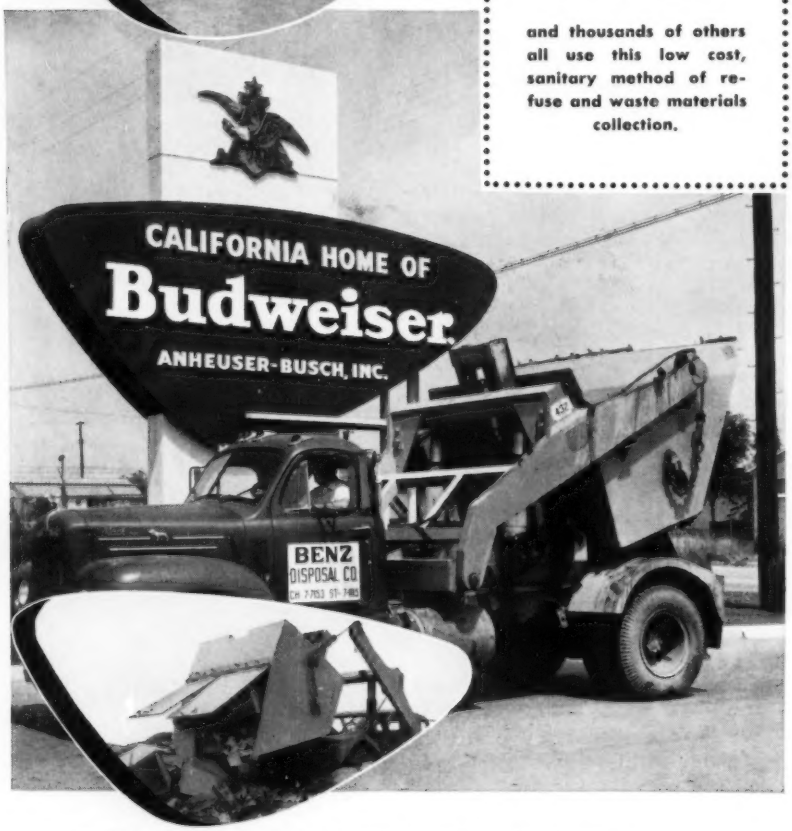
and thousands of others all use this low cost, sanitary method of refuse and waste materials collection.



ANHEUSER-BUSCH, Inc. requires the highest standards of efficiency and sanitation in handling waste materials at its Los Angeles brewery. To maintain this standard ANHEUSER-BUSCH, Inc. uses the DEMPSTER-DUMPSTER SYSTEM. This modern method isolates and controls wastes from the moment it becomes waste and hauls it from the plant-site for disposal. Big steel DEMPSTER-DUMPSTER DETACHABLE CONTAINERS, in the size and design desired, are located at convenient on-the-spot accumulation points. As each is loaded it is picked up, hauled and emptied by a truck-mounted Dempster-Dumpster, operated by only one man, the driver.

Like many companies, ANHEUSER-BUSCH, Inc. contracts the handling to a Dempster-Dumpster System contract-hauler, in this case BENZ DISPOSAL CO.

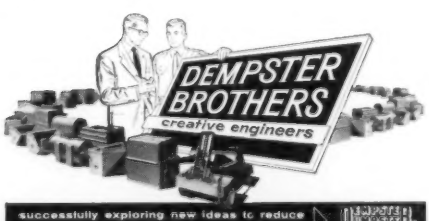
At left you see how each container is handled. Note in pictures upper left that the system was designed for integral plant-placement of Dempster-Dumpster Containers; that in this instance Dempster-Dumpster Container is pit-stationed for easy loading. Note in pictures lower left how Dempster-Dumpster Containers are stationed for yard-collection and dock loading.

You, too, can make substantial reductions in materials handling costs with this modern system — plus reducing fire hazards and effecting tremendous improvements in plant-wide cleanliness and sanitation!

There is a Dempster-Dumpster Container to suit the material, regardless of description. And any number can be handled by one truck-mounted Dempster-Dumpster. Isn't this the system you have been looking for? Write us today for complete information. *Manufactured by Dempster Brothers, Inc.*

New Dempster-Dumpster Bottom Dumping Containers with SUMP BOTTOM eliminate dripping! The SUMP BOTTOM gives you an ALL-PURPOSE CONTAINER for moist, wet refuse as well as dry wastes.

Should your needs call for the use of only a few Dempster-Dumpsters, ask us for the name of the Dempster-Dumpster System Contract-Hauler in your city.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successfully exploring new ideas to reduce your materials handling costs with the.....
DEMPSTER DUMPSTER SYSTEM

DEMPSTER BROTHERS, 597 Dempster Building, Knoxville 17, Tennessee

Suppliers . . .

Jeannette, Pa., as sales engineer, was elevated to chief engineer of the Supercharging division and ultimately became production manager.

In 1946, Lay returned to Cooper-Bessemer to head the Stationary Application Engineering section, and was later promoted to chief engineer, Products division. He later became assistant general sales manager for all Cooper-Bessemer products.

By the action of the board of directors, Lay was elected to vice president and general sales manager in the fall of 1955, the position he has held until his recent appointment.

PETRO-CHEMICAL SUPPLIERS, INC. has moved to its new and larger quarters at 2032 Dunlavy, Houston. **Herschel J. Wood** is president of the company and **Tom W. Rosenstein** is vice-president and general manager. It was also announced that **C. S. Brownfield** has joined the sales and engineering organization.

Petro-Chemical Suppliers serves customers interested in industrial hose, rubber synthetics and a full range of bronze and stainless steels, couplings for all types of hose, as well as mechanical packing, belting and industrial rubber goods.

Farnsworth

Casey

THE ENJAY CO., INC., New York, has announced several personnel changes.

In the Market Development division, **Charles E. Farnsworth,** formerly senior market development engineer, has been appointed assistant manager.

Howlett

Farnsworth joined the company in 1942 as a sales trainee, later serving in New York and Boston as a technical representative. In 1954 he became sales supervisor. He gratuated from Rutgers University in 1941 with a B.S. degree in chemistry.

Richard M. Howlett, formerly with the Paramins Division, has been moved to the Market Development division as senior market development engineer. Howlett was employed by an Enjay research affiliate in 1940 and came to Enjay in 1946 as a technical representative. He graduated from Augustina College in 1935 with an A.B. degree in chemistry. He received his M.S. in Chemistry in 1946 at the University of Michigan.

In the Paramins division, **Brian Casey,** formerly technical representative, has been appointed assistant manager of the division. Casey joined Enjay in 1954 and was

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has proved outstanding as
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Decrease Operating and
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Metallo is your Primary Source for standard and custom metallic Raschig Rings. We design, produce and deliver, for ordinary and difficult extraction processes, directly from this one factory.
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. . . low priced leader for Geiger counting.

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. . . first all-electronic laboratory scaler for automatic counting, either binary or decade.

SC – 32
AMPLISCALER
. . . designed for proportional and/or scintillation counting.

A SCALER FOR EVERY PURPOSE
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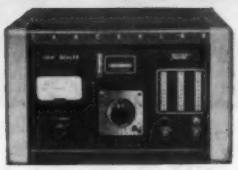
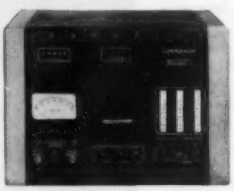
Starting 10 years ago with the Autoscaler, the first all-electronic scaler, Tracerlab has kept pace with the demands of radiation developments and today offers the most versatile and complete line

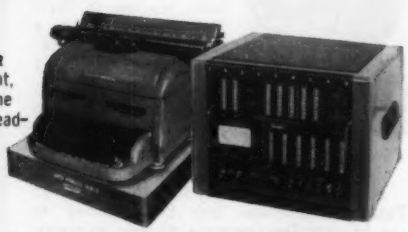


SC – 33A
"1000" SCALER
. . . the standard scaler for scintillation counting.



SC – 18A
SUPERSCALER
. . . first scaler with pre-set time and pre-set count features and versatile plug-in units.

RLI – 15
RESEARCH SCALER
. . . latest development, complete with time count automatic read-out system.



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Suppliers . . .

formerly research chemist for four years with the Sun Oil Co. He graduated from the Massachusetts Institute of Technology in 1950 with a B.S. degree in chemistry and prior to this studied mechanical engineering for two years at Stevens Institute of Technology.

R. A. Short has been named assistant to the manager of the Western division of Enjay Co. Short was first employed in 1946 as a sales trainee. Subsequently he served as a sales representative and supervisor in the alcohols and chemical raw materials field. Just prior to his new assignment he was associated with sales of butyl rubber. Short graduated from Clarkson College of Technology in 1942 with a B.S. degree in chemical engineering.

THE COOPER-BESSEMER CORP. has promoted **Grant C. Woodard** to general sales manager. In this new capacity, Woodard will be responsible for the sale of all company products.

A graduate in mechanical engineering from Cornell University in 1948, Woodard joined the Cooper-Bessemer Sales department that same year as a sales trainee. Later he was assigned to the local sales department where for a number of years he got field sales experience.

In March of 1955, Woodard was advanced to assistant general sales manager, the position he has filled until his recent elevation to general sales manager.

BAILEY METER CO. has named **K. T. Bridgman** manager of the company's Schnectady district office. Bridgman succeeds **J. F. Luhrs** who has been assigned to the Cleveland main office.

Bailey Meter, whose headquarters is in Cleveland, manufactures instruments and automatic controls for the power and process industries.

Bridgman, formerly resident engineer in Springfield, Mass., joined the company in 1926. A registered professional engineer in Massachusetts, he is a graduate of Purdue University and holds a B.S. degree in mechanical engineering.

SCIENTIFIC APPARATUS MAKERS ASSOCIATION has appointed **George E. Lawrence** manager of the association's Washington office. Lawrence succeeds **W. C. Stevenson** who served the association in this capacity since 1943. Stevenson is retiring at his own request.

Lawrence is presently manager of the Bausch & Lomb Optical Co. Washington office and director of the company's government relations. He has been associated with B&L for 18 years.

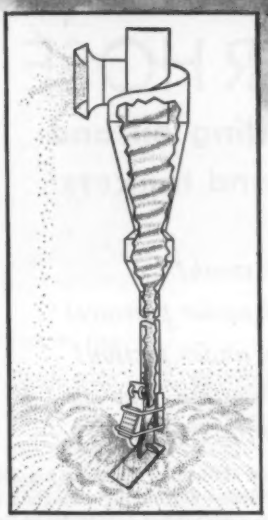
His experience in the Rochester office of Bausch & Lomb includes assignments as process engineer, chief inspector, assistant to vice president and scientific instrument manager, and administrative assistant to the vice president in charge of sales.

Taking his preparatory work at the Case School of Applied Science, Lawrence graduated from Annapolis Naval Academy in 1939. He is a member of the ASME and many other professional and scientific societies.

HOUDRY PROCESS CORP. has named **E. Newbold Black, IV**, a product sales engineer in the chemicals division. He was formerly an assistant chemical engineer in the Development department of the company's Research division at Linwood, Pa.

Positive Dip-Leg Seal
with Catalyst Density
Increased 50% or More...

DUCON
TRICKLE
VALVES



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Ducon Trickle Valves provide greater stability of cyclone operation by minimizing start-up and upset catalyst losses. Increased dip-leg seal catalyst density permits greater thru-put without additional dip-leg length and vessel height. With hundreds of Ducon Trickle Valves in service, the petroleum refinery industry itself has proved their unsurpassed dependability for continuous, trouble-free operation.

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THE Ducon COMPANY INC.

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CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

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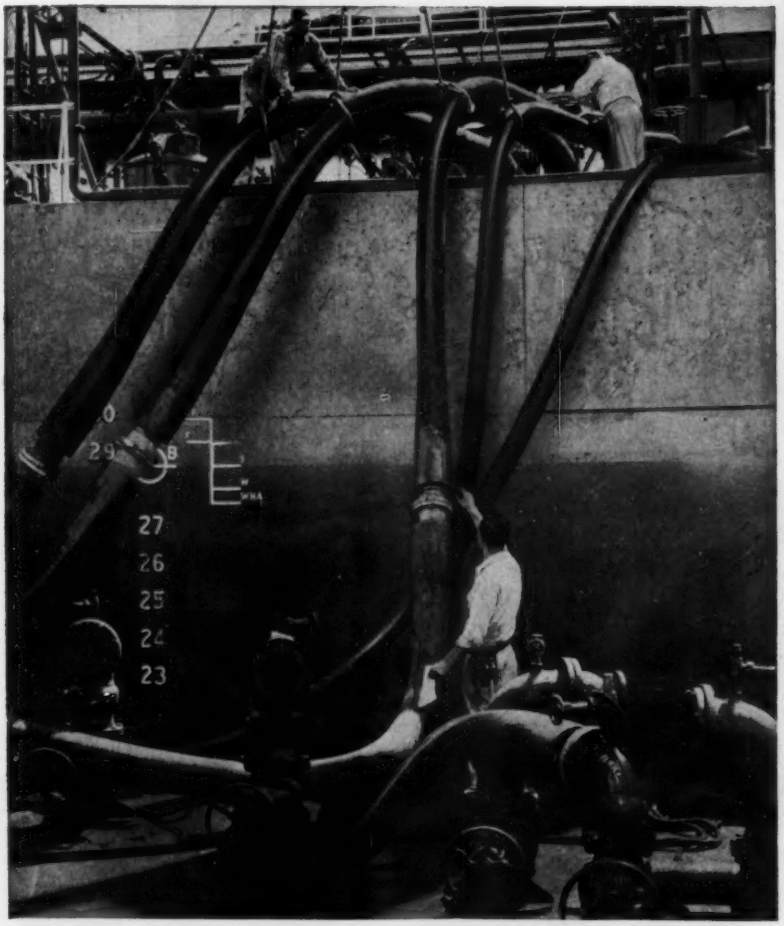

NEW QUAKER HOSE

for loading and unloading oil and gasoline from barges and tankers!

- *Won't kink or crush!*
- *Won't expand under pressure!*
- *Won't collapse under suction!*
- *Superior construction due to nylon cord reinforcement!*

For more information about new Quaker Qua-Flex Oil Transportation Hose—flexible, lightweight and rugged—see your Quaker Rubber distributor today!

Or write:
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H. K. Porter Company, Inc.,
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H. K. PORTER COMPANY, INC.
QUAKER RUBBER DIVISION

Suppliers . . .

Black received his B.S. degree in chemical engineering at the University of Pennsylvania. He served with the U. S. Navy and was a member of the U. S. hockey squad in the 1956 Olympic games in Australia.

BECKMAN INSTRUMENTS, INC., has named **Thomas Scatchard** new director of manufacturing for the Berkeley Division.

Scatchard

Scatchard, formerly plant manager, directs all manufacturing operations for Berkeley high-speed counting and test equipment, electronic analog computers and nuclear instrumentation.

Prior to joining Beckman-Berkeley in January, 1956, Scatchard spent six years with Marchant Calculators, Inc., of Emeryville, serving as manager of the firm's assembly plant. Earlier, he was head of production operations at the Little Falls, N. Y., plant of Cherry-Burrell Corp., manufacturer of dairy equipment.

Scatchard graduated from Cornell University with a B.A. degree. He is a member of the American Society of Tool Engineers and the West Coast Electronics Manufacturers Association.

INTERNATIONAL NICKEL CO., has appointed **Robert D. Schelleng,** a research metallurgist on the staff of the company's Research Laboratory at Bayonne, N. J., supervisor of the Ferrous Castings section.

A 1950 graduate of the University of Michigan with a B.S. degree in metallurgical engineering, Schelleng subsequently held teaching and research fellowships at the same university and was granted a M.S. degree, also in metallurgical engineering, in 1951.

Schelleng joined the staff of the Bayonne Laboratory in 1951 and since that time has conducted research on nickel alloy cast irons and ductile iron.

HOOKER ELECTROCHEMICAL CO., has announced that **John N. Moore, Charles A. Strack, Henry R. Morrison,** and **Matthew S. Bissell** have received new sales department appointments.

Moore, formerly product supervisor—Virgo Salt and Fluorolube, is now supervisor of jobber sales. His former position is filled by Strack who has been in Virgo technical service.

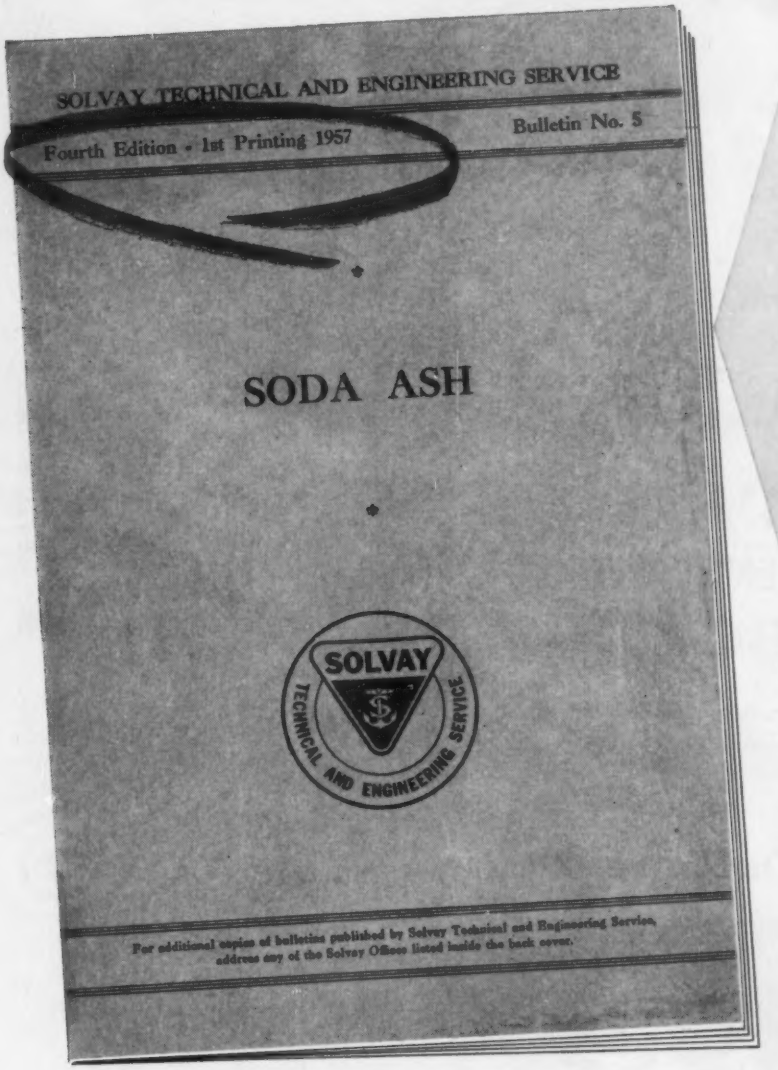
A graduate of Wesleyan University, Moore started at Hooker in 1941 in the manufacturing section of the research department. He transferred to sales in 1949, became Virgo sales supervisor in 1951, and in 1954 was also named Fluorolube sales supervisor.

Employed at Hooker in 1950 as a chemical engineer, Strack holds a B.S. degree in chemical engineering from Cornell University. He has been in technical sales service since 1953.

Morrison, recently released from army training, has been transferred to Los Angeles, as trichlorethylene specialist. He first joined Hooker in 1952 as a chemical engineer in the process study group, following graduation from Pennsylvania

For more data on advertised products, use Readers' Service Cards, last page.

NOW READY—NEW EDITION OF SOLVAY'S BULLETIN No. 5 ON SODA ASH!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Fourth Edition - 1st Printing 1957
Bulletin No. 5
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Up-to-the-minute facts on use—handling—storage of both dry and slurry forms!

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A standard reference for soda ash users the world over—SOLVAY's Bulletin No. 5—is now available in a new revision, the Fourth Edition. In clear, concise style, it presents valuable new, as well as basic data organized in easy-to-find form. This work was achieved through 75 years of close association between America's first producer of soda ash and a wide variety of customers in the glass, paper, textile and other industries.

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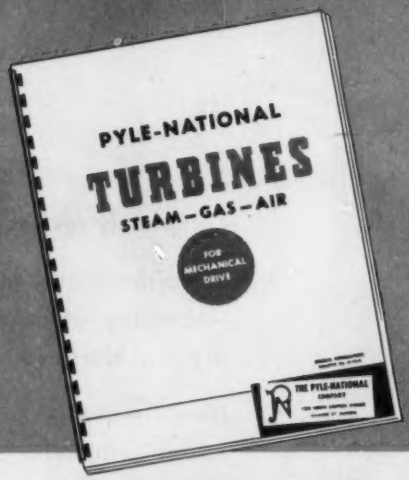
For more data on advertised products, use Readers' Service Cards, last page.

Do you have a mechanical drive problem?



TURBINE SELECTION AND ENGINEERING DATA BOOK

The most complete reference available to answer your questions on turbines . . . at-a-glance information on speeds, B.H.P., pounds-steam/B.H.P.-hour at various steam pressures.

Request your copy today on your company letterhead.

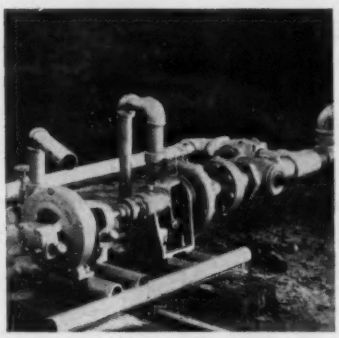
59 years' experience in turbine development

PYLE-NATIONAL TURBINES

¼ to 120 HP for mechanical drive

—the turbines that ask no favors in the refinery or in the field

- Weatherproof!
- Rugged!
- Trustworthy!
- Easiest of all turbines to service and maintain!



Also available: Turbo-Generators (½ to 15 KW)
Turbo-Alternators (60 cycle 3.75 to 25 KVA)

THE PYLE-NATIONAL COMPANY
WHERE QUALITY IS TRADITIONAL
1393 N. Kostner Avenue, Chicago 51, Illinois

SINCE 1897

Branch Offices and Agents in Principal Cities of the U.S. and Canada • Canadian Agent: The Holden Co., Ltd., Montreal • Railroad Export Department: International Railway Supply Co., 30 Church St., New York 7, N.Y. • Industrial Export Department: Rocke International Corp., 13 E. 40th St., New York 16, N.Y.
CIRCUIT CONTROLS • PLUGS AND RECEPTACLES • LIGHTING FIXTURES • FLOODLIGHTS

Suppliers . . .

State University with a B.S. degree in chemical engineering. In 1953 he was transferred to the sales department as sales production coordinator.

Bissell, a 1950 graduate of New York University, is newly employed as a sales representative in the Chicago district. He had been in pharmaceutical sales since 1951, with G. D. Searle & Co., Chicago.

THE GARLOCK PACKING CO., Palmyra, N. Y., has announced the assignment of **T. E. Broomhead** to a sales territory in the northeast section of Ohio. Broomhead was formerly with the Boston office.

WALWORTH CO., has named **Milford H. Luttrell** general sales manager. Luttrell joined Walworth in 1933. He was appointed assistant manager of the Southeastern division in 1944 and made manager in 1949.

Sy

Van Orden

ADSCO DIVISION, Yuba Industries, Inc., has appointed vice president **Arthur H. Sy** to the corporate staff of the organization in San Francisco. He will continue as vice president with responsibility for marketing policy, product development and sales promotion for all divisions of the corporation.

Sy, who for 34 years has been associated with Adsco division and its predecessor, American District Steam division, will move immediately from his home to San Francisco, where Yuba headquarters is located.

Leo J. Van Orden, Glen Ridge, N. J., who has been in charge of Adsco's New York office since 1953, will succeed Sy.

Van Orden graduated from the Newark College of Engineering in 1931. Among the organizations for which he worked before joining Adsco were Hydrocarbon Research, Inc., New York, and M. W. Kellogg Co., Jersey City.

DOWELL INCORPORATED has completed the reorganization of its three eastern United States districts according to **A. C. Polk,** general manager at Tulsa. The area involved in the reorganization program includes all of the states East of the Mississippi River except Michigan.

All of Dowell's industrial services East of the Mississippi River, except Florida, will now be handled from the Cleveland district office. All oil field services, except for Michigan, will be managed from Salem, Ill. Florida industrial chemical services and sales activities will be supervised by Dowell's Houston office. The company's Michigan oil field business will continue to be managed from its Mt. Pleasant, Mich., district office.

All employees of the company who had

For more data on advertised products, use Readers' Service Cards, last page.

CONTINENTAL OIL COMPANY
SHORT JUNCTION
GAS PROCESSING PLANT
MOORE, OKLAHOMA

"and I say it's the reason *WHY* that's important . . ."

. . . I say it's the reason *WHY* — and it's important. Tuloma has that almost indispensable ingredient — HONESTY. Add to that a raw integrity which companies like Continental depend on. Tuloma has the know-how — the men and the equipment.

ENGINEERING DESIGN CONSTRUCTION

TULOMA
BUILDERS, INC.

8500 East 41st • Telephone Riverside 7-1311
P. O. BOX 7036 • TULSA, OKLAHOMA

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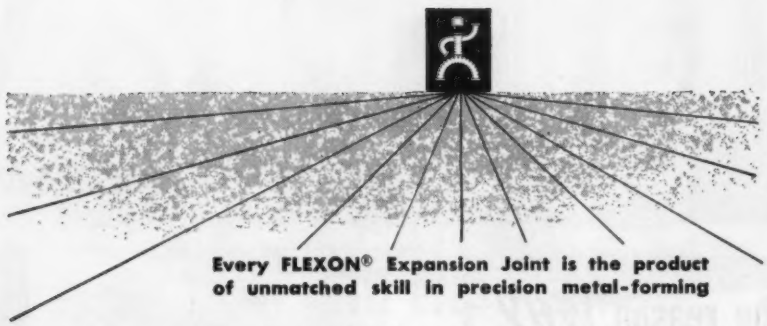
19,862

years of experience



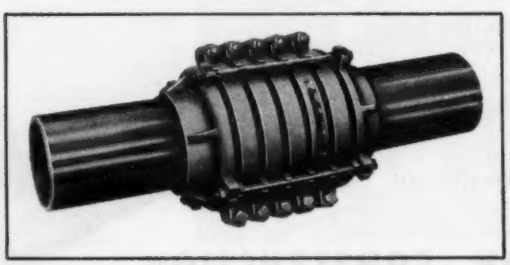
Every FLEXON® Expansion Joint is the product of unmatched skill in precision metal-forming

Experience and skill . . . the combined metal-forming experience of the team of engineers, metallurgists and skilled technicians who produce FLEXON Expansion Joints totals 19,862 years!

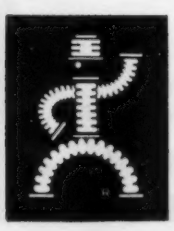
Years of forming and corrugating tubular shapes in metal—flexible metal hose, instrument-type bellows, "impossible" bends and section modulations for aircraft . . . and expansion joints of every kind.

Your dividend of this unequalled experience is expansion joints that you *install and forget*. Free-flexing and controlled-flexing; dual and multiple types; balanced joints and other special designs; all in stainless steel, monel, and other workable alloys. Assured longer service life, through careful analysis of your application, plus skillful manufacture.

Write today for your copy of the Flexon Expansion Joint Design Guide—28 pages of facts about absorbing pipe motion.



EJ-200



Flexonics
corporation

EXPANSION JOINT DIVISION—1336 S. THIRD AVE., MAYWOOD, ILL.

EXPANSION JOINTS | METAL HOSE | NON-METALLIC HOSE | BELLOWS | AIRCRAFT COMPONENTS

Suppliers . . .

been assigned to the Ardmore district will now report to Cleveland. The Ardmore office has been closed and its people transferred to Mt. Holly, N. J., where Dowell has recently completed a service and sales headquarters.

CONSOLIDATED ELECTRODYNAMICS CORP., has appointed **Willard T. Holmes** director of engineering and **Roy K. Stephens** director of manufacturing of the Alectra division. Holmes previously was director of manufacturing for Alectra, and Stephens was manager of the division's printed wiring department.

Prior to his association with CEC, Holmes was head of the quality control department, Triad Transformer Manufacturing Co.; chief engineer, Tetrad Company, Inc.; and engineering vice president, Tartak Electronics. He was director of manufacturing of Electronic Industries, Inc., when Consolidated bought EI in June, 1956, and established the firm as a division, now known as the Alectra Division.

Stephens joined CEC in May, 1956, as a senior product engineer and became manager of the printed wiring department at Alectra in September. Previously, he was director of research, Cec-Bee Chemical Co.; chief chemist, Construction Laboratories, Inc.; and a process engineer with the Convair Guided Missile division. He is a 1949 graduate of the University of Rochester with a B.S. degree in chemistry.

DAVISON CHEMICAL CO. has announced that **Joseph Kapp** has joined its Petroleum Catalyst department as a sales representative, and has been assigned to the Chicago office where he replaces **W. A. Skibbe, Jr.,** transferred to Baltimore headquarters.

Kapp, a native of Hammond, Ind., holds a degree in petroleum technology from Purdue University, and joins Davison from Phoenix Chemical Laboratories.

TRACERLAB, Inc. has announced the addition to its force of **Charles B. Mead** as a sales representative with headquarters offices in Detroit, Mich. Mead who is married and has two children, worked for Commercial Solvents Corp., and served as a Lt(jg) in the U. S. Navy from 1950-55. He attended Siena College in Loudonville, New York where he received his B.S. degree in chemistry in 1950.

THE ENJAY CO., INC., New York, has announced five new sales representatives in the Mid-Atlantic district of the Eastern division.

Glenn W. Boynton will sell alcohols and chemical raw materials in New York City. He was formerly in the Supply department of Esso Standard Oil Co.

Boynton received an A.B. degree in Economics from Wesleyan University and he lives in South Salem, New York.

Richard C. Gazley will sell paramins along the Eastern seaboard. He was formerly with U. S. Testing Corp., Hoboken, N. J., after spending two years in the army.

Gazley received a B.S. degree in chemical engineering from Cornell University. He makes his home in Elizabeth, N. J.

Steven M. Lyons will sell alcohols and

QUICK

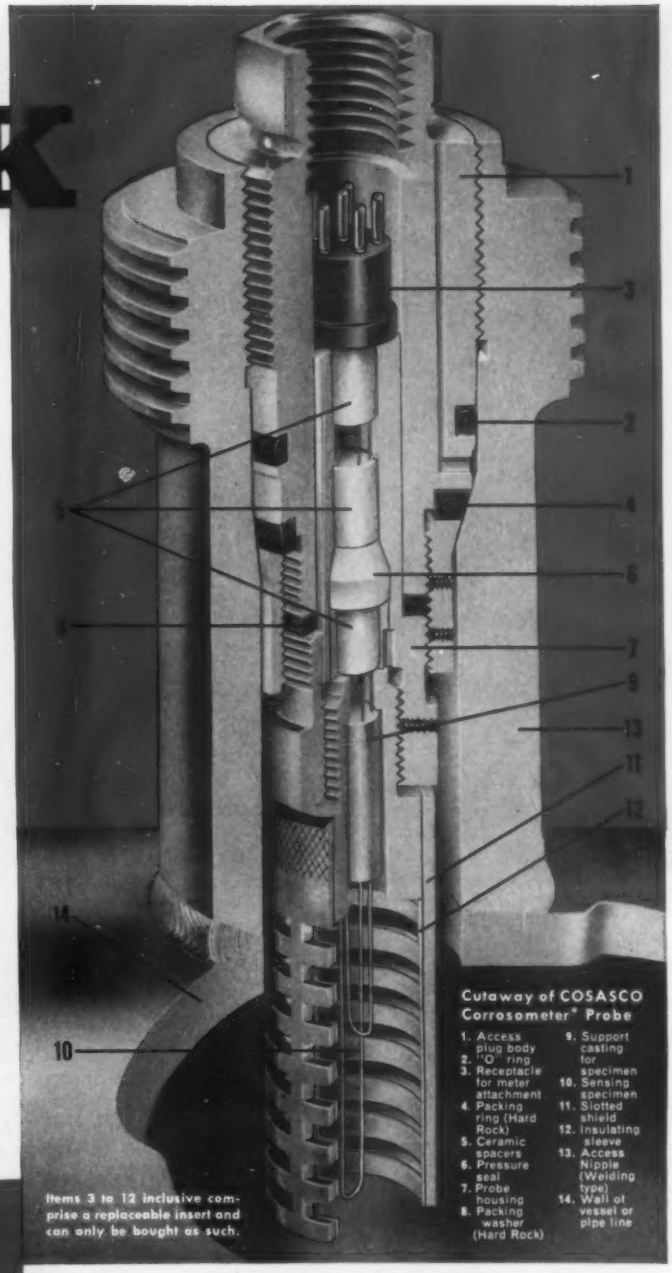
...corrosion readings while on stream...at full operating pressure

Corrosion engineers can now quickly detect and measure rate of corrosion of surfaces within pipe lines, processing vessels and receptacles, without interfering with operations...with this new COSASCO Corrosometer* Probe. Wherever a COSASCO *Access* Nipple can be installed, this probe can be inserted against full operating pressure, for sensing corrosion.

With a special meter connected to the probe, corrosion readings in increments of microinches can be made in as short an interval as 30 seconds. Effects of remedial programs can be determined in days instead of months!

Readings are based on the increase in electrical resistance of a metal specimen as corrosive attack reduces electrical conductivity. Accurate readings are obtained when the specimen is of the same metal as the surface under study.

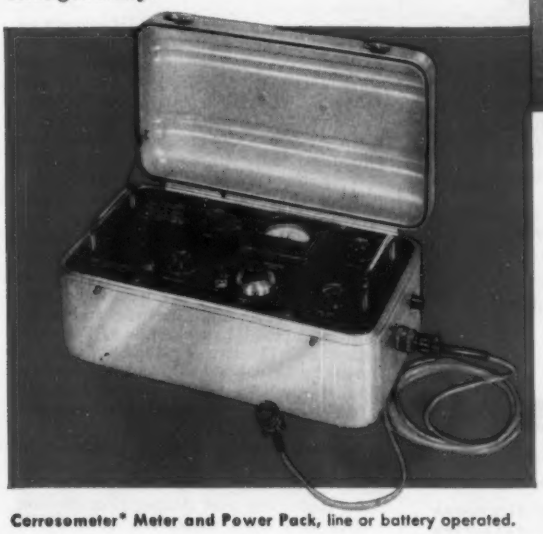
The Corrosometer* Probe is one of several specialized COSASCO *Access* Plugs adapted to corrosion investigation. They include coupon-holder, water-sampler, thermocouple, and hydrogen-probe plugs. All can be supplied in the same OD for interchangeability.



Cutaway of COSASCO Corrosometer* Probe

1. Access plug body
2. "O" ring
3. Receptacle for meter attachment
4. Packing ring (Hard Rock)
5. Ceramic spacers
6. Pressure seal
7. Probe housing
8. Packing washer (Hard Rock)
9. Support casting for specimen
10. Sensing specimen
11. Slotted shield
12. Insulating sleeve
13. Access Nipple (Welding type)
14. Wall of vessel or pipe line

Items 3 to 12 inclusive comprise a replaceable insert and can only be bought as such.



Corrosometer* Meter and Power Pack, line or battery operated.

Is Operating Pressure Keeping You Out?

If you have an entry-against-pressure problem, COSASCO engineers can help you overcome it. Send details and blueprints depicting your problem and the COSASCO solution will be supplied promptly and without any cost to you whatsoever. *Write directly to* COSASCO Division of Perfect Circle Corporation, at the address below.

Protect equipment...Save product

COSASCO

DIVISION OF PERFECT CIRCLE CORPORATION

11655 McBean Drive, El Monte, California *TRADE MARK

Export Office: 3631 Atlantic Avenue, Long Beach, California

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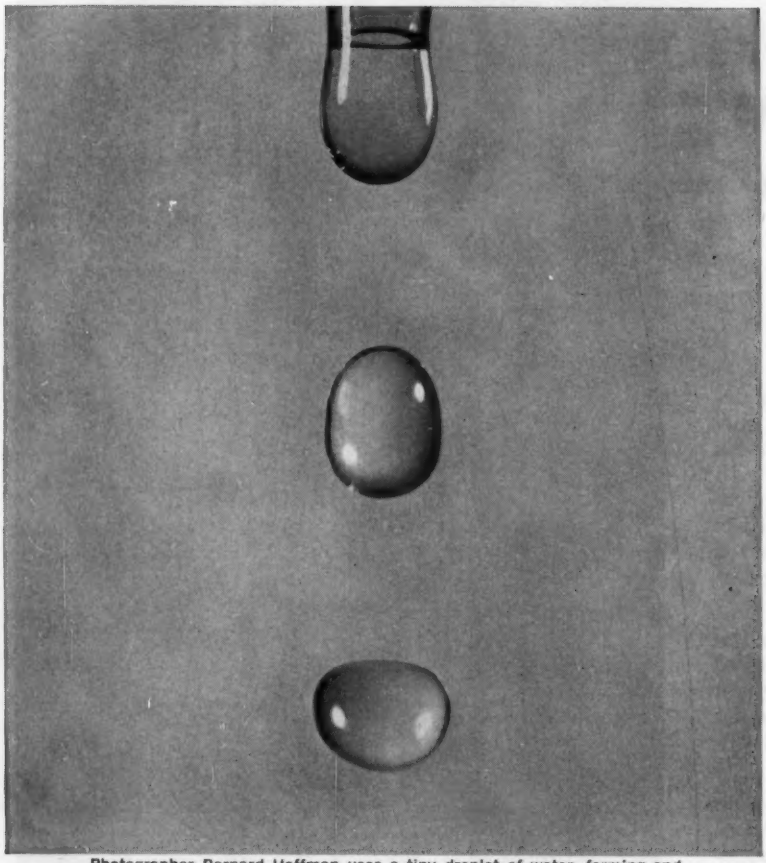

Photographer Bernard Hoffman uses a tiny droplet of water, forming and falling, to illustrate time sequence.

Controlling Time in Fluid Engineering

Even in simple hydrodynamic situations like the one pictured above, time sequence is measured in micro-seconds. More often than not, other factors—such as pressure, volume and flow—all tend to complicate fluid time control. That's where the engineering leadership of S. Morgan Smith can help you most.

SMS Rotovalves, for example, will give you the closest control of closing time . . . as quick as one second or as slow as needed. Their fast initial shut-off limits reversal of flow, and closure is positive and drop-tight. Rotovalves are easier to operate, requiring less power for mechanical or electrical operation, and their full line opening means less head loss and lower pumping costs.

SMS offers you a complete line of standard Rotovalves, Ball Valves and R-S Butterfly Valves, as well as special application engineering help. To obtain full information, call our nearest representative, or write S. Morgan Smith Company, York, Penna.

S. MORGAN SMITH HYDRODYNAMICS

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

Rotovalves • Ball Valves • R-S Butterfly Valves • Free-Discharge Valves • Liquid Heaters • Pumps • Hydraulic Turbines & Accessories

Suppliers . . .

chemical raw materials in northern New Jersey, northeastern Pennsylvania and western New York. He was formerly with the Esso Research and Engineering Co.

Lyons received a B.S. degree in civil engineering at Virginia Polytechnic Institute. He lives in Westfield, N. J.

James I. Kennedy will sell alcohols and chemical raw materials in Brooklyn, Staten Island, Westchester County and lower Connecticut. He was formerly with Dow Chemical Co.

Kennedy received a degree in Economics from Boston College. He now makes his home in Midland, Mich.

Elmer F. Smith, Jr., will sell alcohols and chemical raw materials in southern New Jersey, southeastern Pennsylvania, Delaware, eastern Maryland and northern Virginia. Prior to his affiliation with Enjay Smith was with Archer Daniels Midland in the New York area and the E. I. duPont de Nemours and Co., Inc.

Smith received a B.S. degree in chemical engineering from Lehigh University. He lives in Fanwood, N. J.

DAVISON CHEMICAL CO., division of W. R. Grace & Co., has appointed **Edward J. Bieberich** plant superintendent of its new desiccant manufacturing plant at Gallup, N. M. In this position, Bieberich will have charge of all purchasing, production and shipping of the company's new desiccant.

Bieberich, a native of Baltimore, joined Davison in 1935 and was employed in the production organization of the Curtis Bay plant until 1945, at which time he entered the production planning group, advancing to production planning supervisor.

BALDWIN-HILL CO., Trenton, N. J., has acquired all the stock of the Federal Building Material Co., Sand Springs, Okla., and will operate this company as a wholly owned subsidiary.

The acquisition of the Sand Springs plant near Tulsa marks a step in the expansion of Baldwin-Hill's Southwestern operation. **Carl L. Louchner,** vice president of Federal Building is joining Baldwin-Hill.

FISCHER & PORTER CO. has promoted three members of its Data Reduction and Automation division.

John Roback, formerly chief project engineer, became engineering manager. Roback has been active in the development of data reduction equipment for the past 12 years, having been with the Electrical Equipment Co., prior to its purchase by Fischer & Porter in 1954. Roback obtained his B.S. degree in electrical engineering from New York University.

C. R. Lambert, who has been named operations manager, joined F&P from Daystrom, Inc., where he was an administrative engineer. Previously, Lambert had been with the Wick Engineering and Construction Co., the Ballistic Laboratory at Aberdeen Proving Grounds, and at the Palmer Physical Laboratories at Princeton University. He is a graduate of the Air Corps Technical School, and has had additional study in mathematics and physics at Alabama Technical Institute and Princeton University.

Norbert Weber, former manager of F&P's International division, has been appointed assistant sales manager of the Data Reduction and Automation division. Weber had been associated with F&P's

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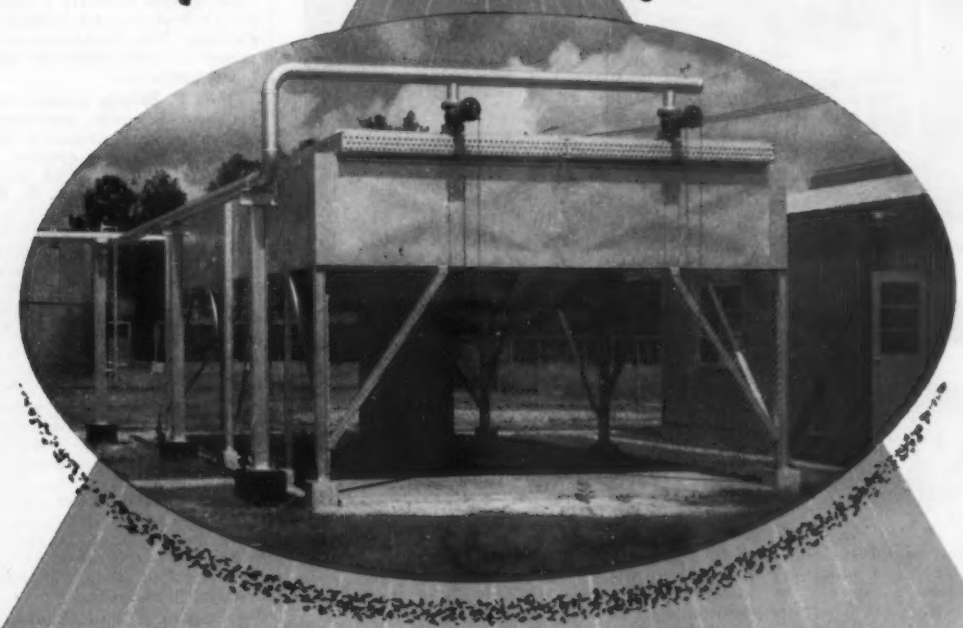
SMITHCO

Unequalled Performance



From the leading manufacturer of air cooled heat exchangers comes the most advanced designing and highest quality equipment on the market today.

Smithco's extensive background plus their unequalled engineering and manufacturing ability, establish them as leaders in air cooling.

For air cooled heat exchangers of unequalled performance always look to Smithco.

SMITHCO ENGINEERING INC.

P. O. BOX 3171 . . . TULSA, OKLAHOMA

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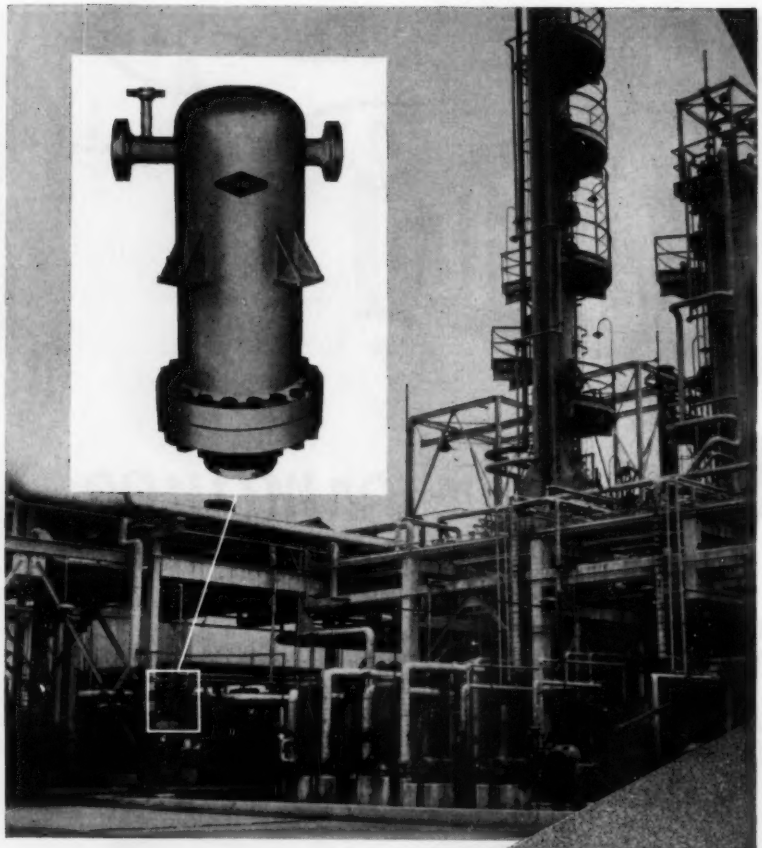


Esso *selects*

POROUS STAINLESS STEEL

CUNO

PORO-KLEAN
FILTER
for HYDROFINER

To remove catalyst fines from the Hydrofiner outlet stream – and thus prevent catalyst poisoning in the "reformer" – Esso selected a Cuno Poro-Klean Filter for its Baltimore, Maryland refinery. The fluid, heavy virgin naphtha of approximately 52.7 API, reaches the filter at 350°F. The Cuno Filter is a completely standard unit. Housing includes integral arrangements for in-place cleaning by backflushing and is built to meet A.S.M.E. Code requirements. For easy inspection, individual cartridges of sintered stainless steel are employed. The porous metal filter material manufactured by Cuno features a carefully controlled porosity that insures uniform fine filtration with complete removal of all catalyst particles.

Cuno Filters are now in service throughout the Petroleum Industry handling–

PRODUCT STREAMS **COMPRESSED AIR** **PROCESS STREAMS**
CHEMICALS **STEAM** **SERVICE FLUIDS** **ADDITIVES**

WHATEVER YOUR FILTRATION PROBLEM . . . you can look to Cuno for the best possible unit to meet *your* specific needs. Remember ONLY CUNO offers you a truly complete line that includes all 5 types of filter media –

EDGE-TYPE • WIRE-WOUND • SCREEN • FIBER CARTRIDGE • POROUS METAL

CUNO **CUNO ENGINEERING CORPORATION**

3409 SOUTH VINE STREET, MERIDEN, CONN.

Designers and Manufacturers of Filters for Over Thirty Years

Suppliers . . .

Netherlands affiliate, Fischer-Van Winkel N.V., at The Hague. Prior to this association, Weber had been with the Beckman Instrument Co. as senior project engineer and as sales manager. He is a graduate of the Ecole Centrale des Arts et Manufactures, Paris.

Louis Aricson, administrative vice president of Fischer & Porter, will become responsible for the general management of the Data Reduction and Automation division. **Robert Stern,** former administrator of this division, has, by mutual consent, resigned his connection with Fischer & Porter Company.

BECKMAN INSTRUMENTS, INC., has formed a new Systems division in an organizational expansion.

With headquarters and manufacturing facilities at Anaheim, Calif., in addition to a plant in Richmond, Calif., the new Systems division consolidates technical experience and facilities of systems development groups formerly a part of the company's Berkeley and Scientific Instruments division. New buildings are being completed in both cities to house the combined operation.

John F. Bishop, general manager of the Beckman Scientific Instruments, Berkeley and Process Instruments divisions, will head the Systems division, with **T. C. Fletcher** as director of engineering and manufacturing, and **W. E. Rianda** as director of marketing.

HARBISON-WALKER REFRACTORIES CO., has appointed **Robert R. Bowman** district sales manager of the Buffalo, N. Y., sales area. He had been a sales representative in the company's Buffalo office for the past five years.

Bowman is a graduate ceramic engineer from Alfred University. His experience with Harbison-Walker includes a three year period as sales representative in the Cleveland area and three years in the Technical Sales department.

DAVISON CHEMICAL CO., division of W. R. Grace & Co., is establishing a new office at Tulsa, Okla., to maintain sales and technical contact with refineries in the area on behalf of the company's Petroleum Catalyst department.

In charge is **W. L. Banks,** who has previously operated out of the Davison Houston office.

BABCOCK & WILCOX CO., vice president **J. E. Brinckerhoff** was elected president of The Refractories Institute, at the annual meeting of the board of directors and membership held at The Greenbrier, White Sulphur Springs, W. Va.

Brinckerhoff was born in New York City and graduated from Cornell University in 1917 with a B.S. degree in mechanical engineering. He has been with B&W since 1918, serving in various capacities in the Refractories division of the company.

The Refractories Institute is a national trade association of refractories manufacturers in the United States, Canada and Mexico.

DE LAVAL STEAM TURBINE CO., has appointed **W. J. Mongon** manager of the Marine Standard Products department and **J. E. Gutzwiler** assistant chief engi-

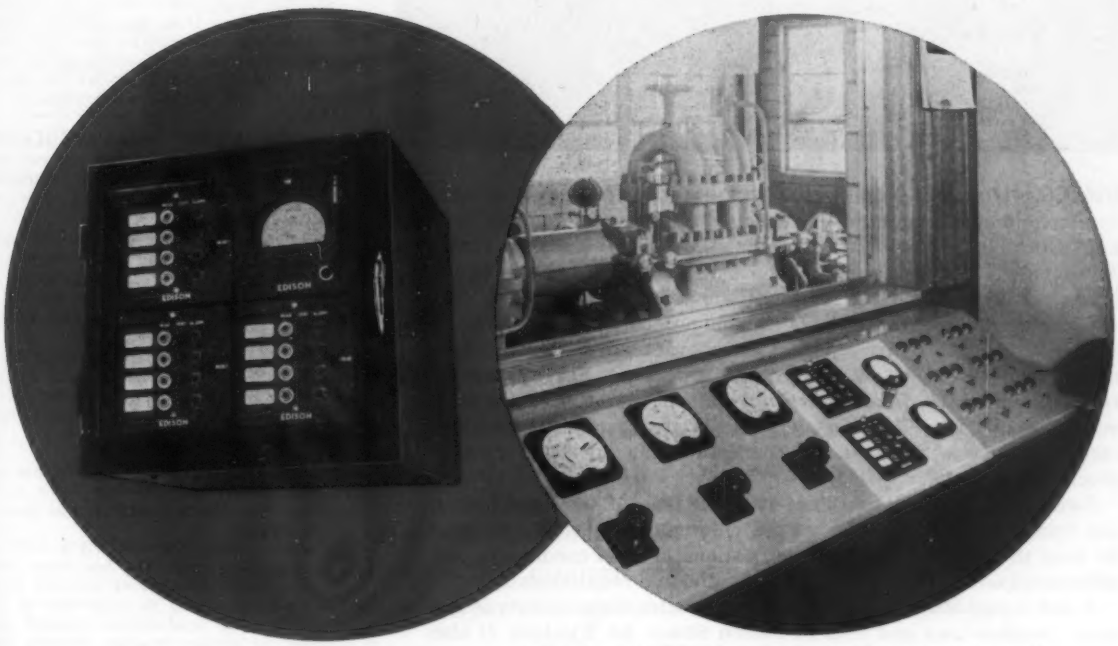
For more data on advertised products, use Readers' Service Cards, last page.

HOW EDISON'S OMNIGUARD PREVENTS PUMPING STATION SHUTDOWN FOR SUN OIL

Booster station shutdowns are prohibitively expensive. At the Sun Oil Company's pumping station at Rochester, Michigan, crude oil is pumped 24 hours a day, 7 days a week from Toledo, Ohio to Canada. One motor or pump shutdown would cost Sun Oil thousands of dollars in both maintenance and production costs.

The Edison Omniguard is used by Sun Oil for alarm and control purposes in connection with the operation of two major pieces of equipment — a 500 hp motor and a 6 stage centrifugal pump. Seven points are under constant surveillance by the Omniguard apparatus; namely, the two motor bearings, the two pump bearings, the two pump seals, and the pump case.

The alarm system at each point is pre-set for a given temperature, automatically warning the operator of any rise in temperature beyond the pre-set point and simultaneously shutting down the unit to prevent damage to major equipment in the pump station. All Omniguard temperature controls are located in a desk type console installed in the control room.



The following Omniguard features prompted Sun engineers to specify it for the Oakland installation:

1) Fast response
2) Quick adjustment of pre-set points
3) Ability to alarm and/or shut down selected points
4) Small physical dimensions of the sensing element
5) Explosion-proof construction at sensing element
6) Associated equipment can be installed immediately

Write for more technical details to:

McGRAW EDISON

Thomas A. Edison
INDUSTRIES
INSTRUMENT DIVISION
96 LAKESIDE AVENUE
WEST ORANGE, N. J.

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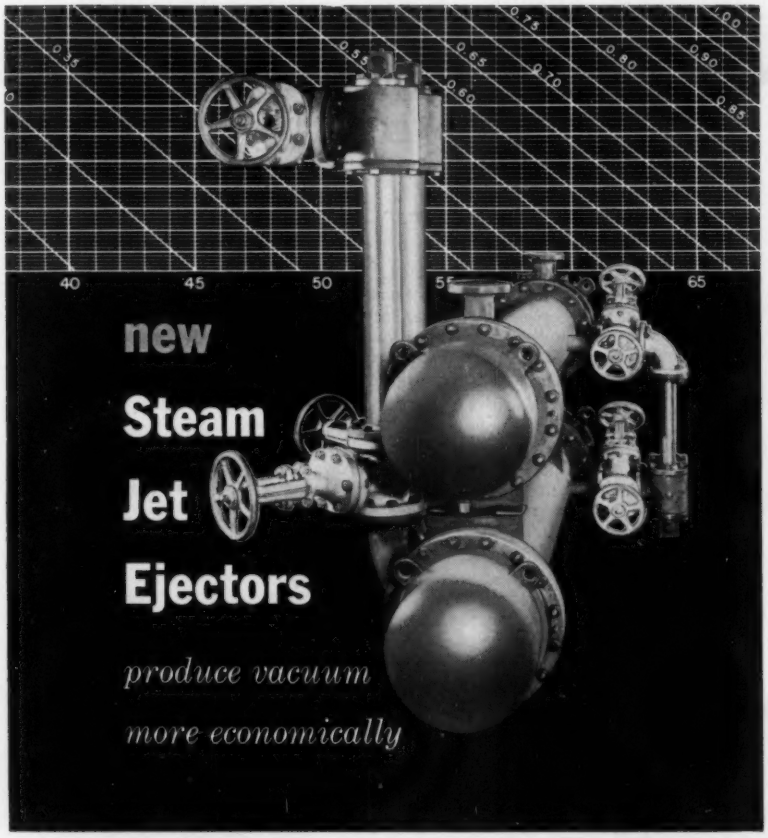


SWECO introduces a complete new line of steam jet ejectors, available in single and multiple stages and in a wide range of sizes and materials. Entirely new designs incorporate the most recent developments in the field—to meet the vacuum requirements of the power and process industries flexibly and efficiently.

Ejectors, the most widely used vacuum-producing devices, are particularly applicable where condensable vapors or corrosive substances must be condensed. SWECO's improved construction utilizes corrosion-resistant materials to protect the unit while in operation and to minimize rusting during shut-down. The units are generously designed, easy to service, with ample test connections for quick performance checks in the field.

SWECO Steam Jet Ejectors are available from 1" to 8" and larger, and from 1 to 6 stages. For extra flexibility, any number of units may be used in parallel. Various combinations of inter-condensers and after-condensers can be provided for individual requirements.

A new 8-page bulletin describes and illustrates design, construction, sizes, combinations and uses of SWECO Steam Jet Ejectors. It also includes a set of valuable Dalton's Law charts with instructions to determine the relationship between percent air in various air-water vapor mixtures vs temperature of the mixtures for various pressures. Write for your copy. It's Bulletin M-4-333.

See SWECO *equipment at the 26th Exposition of Chemical Industries, New York Coliseum, December 2-6, Booth 1307.*

SWECO

Southwestern Engineering Company
4800 Santa Fe Avenue, Los Angeles 58, California
LUdlow 3-6262 - Cable: SWECOLA
ENGINEERS AND CONSTRUCTORS...MANUFACTURERS

Suppliers . . .

neer of the Standard Products department with responsibilities over worm gear and Imo pump engineering. Both will report to **M. B. Sennet,** manager of the Standard Products department.

ALCO PRODUCTS, INC. has announced the appointment of **Arnold A. Hanson,** Wheaton, Ill., as exclusive agent for ALCOTWIN heat exchangers and other longitudinal finned-tube products in a wide area of the Midwest.

Hanson

Hanson will represent ALCO in Minnesota, Iowa, Wisconsin, the Upper Michigan Peninsula and in Northern Illinois and Northern Indiana.

He is associated with the Industrial Process Equipment Co., and maintains his office with that organization in Wheaton. Industrial Process also represents the Clark Manufacturing Co., Texsteam Corp. and Industrial Research and Design, Inc.

Hanson holds a B.S. degree in mechanical engineering from the Chicago Technical College. He has had several years of experience as a project engineer engaged in development work on steam generators and heating equipment.

MINNEAPOLIS-HONEYWELL REGULATOR CO., appointed 141 sales and service engineers to some 90 offices of the company's Industrial division during the past six months.

Assignment of the new men—71 sales engineers and 70 service engineers—was part of a planned expansion program to assure the division a position in the acceleration of automatic control and instrumentation.

The addition of the new men, all graduates of the division's 22-year-old Instrumentation Education Center, Philadelphia, increases the Industrial division's field force to more than 600 men.

CONSOLIDATED ELECTRODYNAMICS has appointed **Robert R. Mawson** sales manager for Transducer products. The post is newly created.

Mawson joined Consolidated in 1951 as an engineering aide. He has been with the company's Transducer division since that time, advancing to supervisor of the test laboratory, application engineer specializing in pressure-sensing devices, and project chief for special electronic pressure-sensing equipment.

Previously, Mawson was an electronic technician with North American Aviation, Inglewood, Calif., and Land-Air, Inc., Alamogordo, N. M.

HOOKER ELECTROCHEMICAL CO., Niagara Falls, N. Y., has integrated the sales of Oldbury Products into the Hooker chemical sales department under **John S. Coey,** manager-eastern sales. The following appointments of Oldbury sales personnel were also announced.

Robert B. Boyd, formerly sales manager, Oldbury Products, has been appointed product manager-organic chemicals. **Fred H. Berggren,** who had been assistant sales

For more data on advertised products, use Readers' Service Cards, last page.

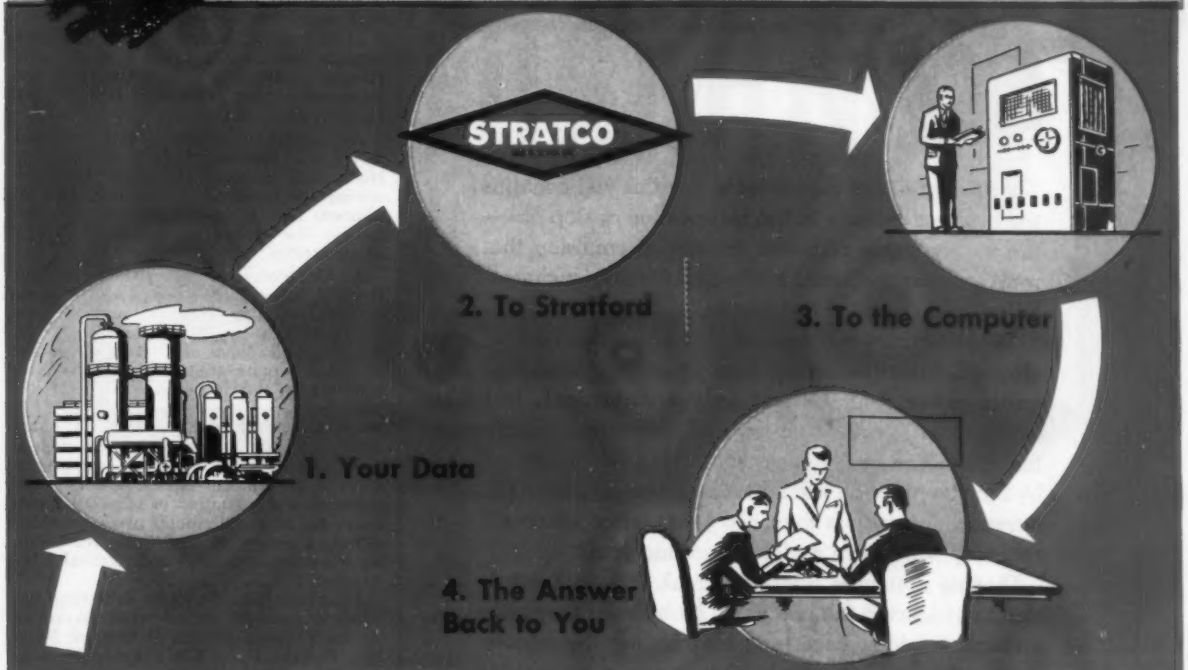
STRATFORD ANNOUNCES

ELECTRONIC COMPUTATION...

To Provide Optimum Process Designs of

STRATCO
Reg. U. S. Pat. Off.

EFFLUENT REFRIGERATED* ALKYLATION UNITS



Accurate Information Furnished Quickly on the Best Design to Fit Your Feed Stock and Other Requirements

There is no cost or obligation involved. Just send us your data and we provide process flow diagrams with complete overall material balances best suited for your operation . . . ordinarily within 48 hours.

Alternate designs to fit various feed stocks, octane levels and other conditions, available if desired. Contact us for details of this time and money saving service.

Representatives
D. D. Foster Co., Pittsburgh
Lester Oberholtz, Los Angeles
Rawson & Co., Houston
F. J. McConnell Co., N.Y.

*Licensed by Stratford Engineering Corporation.
We cooperate with your contractor in plant design.

STRATFORD ENGINEERING Corporation
612 West 47th St. — PETROLEUM REFINING ENGINEERS — Kansas City 12, Mo.

For more data on advertised products, use Readers' Service Cards, last page.

Not the bottle, but the contents. For this vial contains the greatest obstacle in the reclamation of slop oils—the highly stable oil/water interfacial emulsion that remains after the usual settling, skimming, sedimentation, and chemical treatment.

Dicalite filtration breaks this emulsion...and slop oil filtration units now operating with Dicalite prove that it's not only economical, but profitable! Reports from several refineries indicate that the value of the separated, clean oil recovered by Dicalite filtration will amortize the entire cost of the filtration unit in less than two years, after which oil recovery will return a clear operating profit.

Dicalite diatomite filteraids break this tight emulsion by rupturing the minute oil globules as they pass through the filter cake, and by trapping the minute solids which help to make this emulsion so stable. After filtration, clean oil and water separate easily into distinct layers on standing. The water contains so little oil that it may be re-cycled for process water in some applications, or may be discharged to waste without violating the stream pollution laws of any state.

Write today for more complete information.

Dependable GLC GREAT LAKES Dicalite DIATOMACEOUS MATERIALS

DICALITE DIVISION | Great Lakes Carbon Corporation, 612 S. Flower St., Los Angeles, Calif.

Suppliers . . .

manager, Oldbury Products, is now product supervisor-chlorate chemicals.

Joseph I. Rue, Detroit, now reports to Hooker's Chicago office. **John W. Johnstone, Jr.**, Cincinnati, has headquarters at the Niagara Falls main office. **Charles H. Foster, Jr.**, Philadelphia, reports to the Philadelphia sales office. **James T. Whelen**, New York, will use the company sales office in the Lincoln Building as his headquarters.

BECKMAN INSTRUMENTS, INC., has appointed **Roy W. Holm** manager of employee relations for its Helipot division in Newport Beach, Calif.

Holm, associated with the Beckman organization since 1953, is a graduate of Illinois Institute of Technology and was employed for six years with International Harvester Co., in Chicago.

Among other departmental promotions, **David A. Hamlin**, former assistant to Holm, will become wage and salary administrator for Beckman-Helipot. **Jack A. Warren**, also a managerial assistant, will assume the duties of employee service administrator.

A University of Maryland graduate, Hamlin formerly worked for Goodyear Aircraft Co., in Phoenix, and General Telephone Co. in Santa Monica, Calif. Warren, a graduate of UCLA, joined the Beckman organization following service with the U. S. Air Force.

BECKMAN INSTRUMENTS, INC., has appointed **Robert J. Baumann** director of marketing for the Scientific Instruments division. He will be responsible for overall planning and execution of marketing programs for all the division's products which include a variety of analytical instruments for scientific, industrial and medical laboratories.

Baumann joins Beckman following two years as manager of industrial marketing for the O-Cel-o division of General Mills, Inc., Buffalo, N. Y. His professional background also includes managership of marketing research for General Electric Co.'s Chemical division, Pittsfield, Mass.; sales management for GE's Silicone Products

Be Sure To Check This Month's Classified Section in REFINER

Need Engineers - Technical Personnel? Try a Classified Ad in Petroleum REFINER.

QUICK! ECONOMICAL! RESULTFUL!

Help Wanted! Classified Ads in Petroleum REFINER get the job done.

...your low-cost key to high octane

Atlantic's Catalytic Reforming Process continues to prove its ability in giving superior results on a broad variety of feed stocks. Catforming's simplicity brings savings through increased efficiency every step of the way—actually eliminating many profit-robbing intermediate steps.

Regardless of the volume of your charge stock, Catforming deserves your attention. One major reason that Catforming has "proved out" commercially is attributable to Atlantic's broad experience in all phases of petroleum refining and processing.

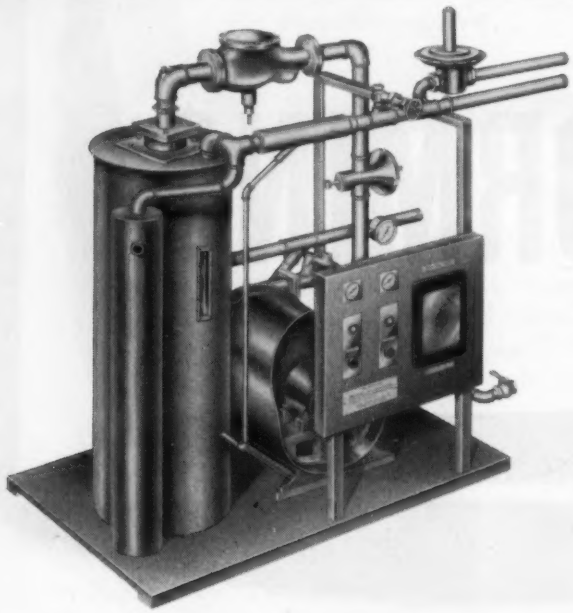
We invite your inquiries on Catforming. Write or wire The Atlantic Refining Company, Research and Development Dept., P.O. Box 8138, Philadelphia 1, Pa.

ATLANTIC

it's the CATALYST that counts

For more data on advertised products, use Readers' Service Cards, last page.

THE NEW SUB-X
INERT GAS GENERATOR
by THERMAL



A compact . . .

economical source of inert gases

THERMAL'S SUB-X generator offers unsurpassed operating economy and efficiency. Its unique design utilizes submerged exhaust of combustion products and permits the use of river water or other low-cost water supply as coolant.

The SUB-X generator is built around the THERMAL burner which can be fired with gas or distillate oil. Because of the burner's high heat release characteristics, the SUB-X generator eliminates refractory and reduces maintenance costs. Each unit is supplied as a complete package with all control and safety equipment. Standard models are available in capacities up to 35,000 SCFH of inert gas. Larger capacity units can be designed to your specifications.

WRITE FOR BULLETIN #114

OTHER THERMAL PRODUCTS & SERVICES
Gas, Oil, Combination Burners • Heat Exchangers • Submerged Combustion • Air Heaters • Combustion and Heat Transfer Engineering

THERMAL
Thermal Research & Engineering Corp.
CONSHOHOCKEN • PENNSYLVANIA
REPRESENTATIVES IN PRINCIPAL CITIES

Suppliers . . .

department, Waterford, N. Y.; and chemical market research and sales development for Standard Oil Co. (Indiana).

A native of Elmhurst, Ill., Baumann received his B.S. degree in chemistry from Elmhurst College and his M.S. degree in organic chemistry from the University of Illinois.

TRACERLAB, INC., board of directors has elected **Homer S. Myers** to fill the newly created post of vice president for marketing. Myers was one of the founders of the firm in the nuclear industry and has been general manager of its Industrial division. The new marketing division will implement the firm's marketing activities with responsibility for the sale of the company's nuclear and industrial products and services.

Goldsby

Hamilton

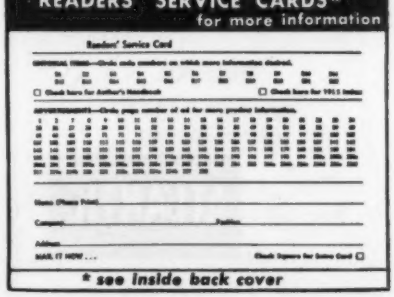
CHICAGO BRIDGE & IRON CO., has appointed former vice president and formerly general sales manager, **Fred L. Goldsby,** assistant to the president. **S. C. Hamilton,** formerly district sales manager, Houston, has been made a vice president and general sales manager with headquarters in Chicago.

K. W. Lange, formerly with the firm at the San Francisco sales office, has been appointed Houston district sales manager.

Goldsby, who joined CB&I in 1927 in the Chicago shop, has worked in the Operating department; as assistant to the chief engineer; in the Research department; and as manager of the company's Foreign Erection department and export manager in New York. He has been general sales manager and a director since 1954. Goldsby attended Bradley University and the University of Illinois, from which he received a B.S. degree in civil engineering in 1927.

Hamilton, district sales manager in Houston since 1940, and a director of CB&I since 1946, joined the company in 1928 in the Engineering department at

use these
READERS' SERVICE CARDS*
for more information

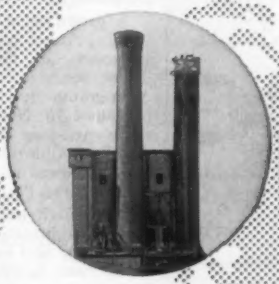


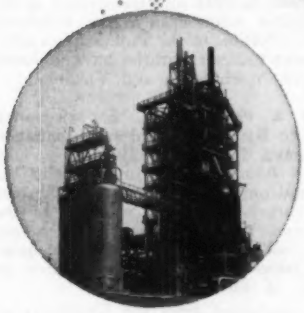
* see inside back cover

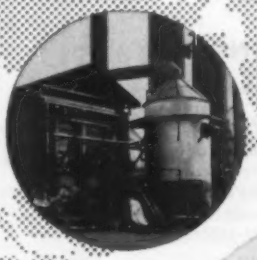
throughout the world...

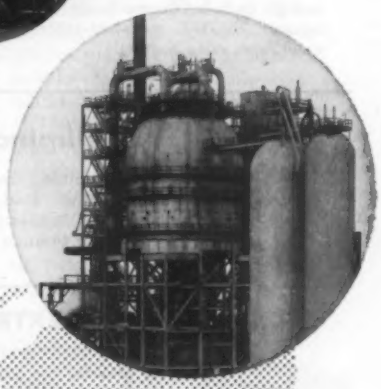
A. P. GREEN

Serves the Petroleum Refining Industry with a Complete Line of High Quality Refractory Products









The petroleum industry throughout the world, relies on A. P. Green high quality refractories for dependable service in thermal and catalytic cracking units, heaters, boilers, stacks, et cetera.

A world-wide network of A. P. Green distributors with engineers experienced in petroleum refining is always ready to help you select the right refractories to do the best possible job ... at the lowest cost. For one dependable source of a complete line of refractories write ...

A. P. Green
REFRACTORY
PRODUCTS

Distributors in the Principal Cities of the World

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

PLANTS: Mexico, Mo. • Woodbridge, N. J. • Sulphur Springs, Texas Jackson, Oak Hill, South Webster, Ohio • Philadelphia, Pa. • Troy, Idaho
In Canada: **A. P. GREEN FIRE BRICK COMPANY, LTD.** Toronto 15, Ontario
In England: **LIPTAK FURNACE ARCHES, LTD.** London, England

For more data on advertised products, use Readers' Service Cards, last page.

INSTALLING LIQUID LEVEL GAGES

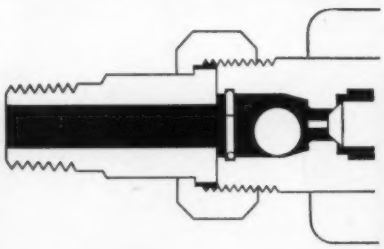
Penberthy "FLOATING SHANK"

lines up off-center holes

Center-to-center variations of vessel tappings or gage assembly can cause costly, inaccurate mounting.

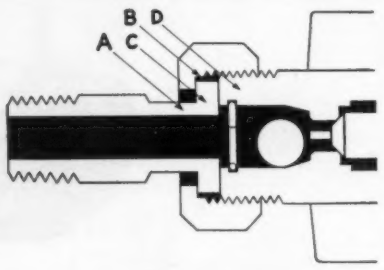
STANDARD SHANK

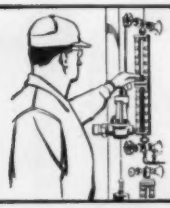
Minimum tolerance between union nut, nipple, and nipple flange prevents *any* corrective movement to compensate for inaccurate tapping. Gage and valve assemblies must either be "force-fitted" or vessel retapped.



FLOATING SHANK

Recessed neck (a) plus wide union opening (b) permit 3/16" movement of flange (c) in ANY direction. Together, "floating shanks" on top and bottom gage valves compensate for off-center tapping errors as high as 3/8". Ground flange (c) assures TIGHT metal-to-metal union with valve body (d).

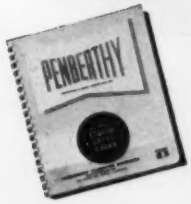




...eliminates mounting strains

By permitting freedom of movement up to 3/8" in ANY direction, Penberthy "floating shank" principle protects against mounting stresses . . . allows gage and valve assemblies to seek TRUE center-to-center position between inaccurately tapped holes.

AN EXCLUSIVE EXTRA AT NO EXTRA COST



- cuts installation time and replacement costs by 50%
- provides true gage and valve alignment on incorrectly tapped vessels
- eliminates "force-fitting" and subsequent strains on gage and valve assemblies
- prevents possible damage to entire installation
- reduces unnecessary glass breakage due to gage distortion

WRITE for Catalog 36 showing complete line of liquid level gages and valves, Standard or special assemblies available through local suppliers or direct.

PENBERTHY MANUFACTURING COMPANY *Division of Buffalo-Eclipse Corporation*
Dept. R 1242 Holden Avenue Detroit 2, Michigan

Everywhere... you're seeing more **PRODUCTS BY** PENBERTHY

EJECTORS
INJECTORS
CYCLING JET PUMPS
LIQUID LEVEL GAGES
GAGE VALVES
SUMP PUMPS

Suppliers . . .

Chicago. He attended grade and high school in his home town, Trenton, Mo., and is a 1929 graduate of Iowa State College, with a B.S. degree in civil engineering.

Lange joined Chicago Bridge & Iron in 1941 in the Chicago Erection district. Born in 1916 in Portland, Ore., he graduated from the Oregon State College in 1939 with a B.S. degree in civil engineering and from Yale University in 1941 with an M.S. degree.

SOLVAY PROCESS DIVISION, Allied Chemical & Dye Corp., has appointed **Verne W. Aubel, Jr.** assistant director of sales. Named to succeed Aubel as manager of Solvay's Philadelphia sales branch was **Kenneth M. Dillabough.**

A graduate of Pennsylvania State University, Aubel joined Solvay in 1939 as a salesman at the Philadelphia branch. Three years later he was assigned to the Ammonium and Potassium Products Department in New York. In 1946 he became assistant to the manager of the Calcium Chloride department and later was appointed manager. Since 1954 he has managed the Philadelphia sales branch.

Dillabough holds a B.S. degree in business administration from Syracuse University. He was employed by Solvay's sales department in 1926 and transferred to the Philadelphia sales branch the following year. In addition to the Philadelphia area, Dillabough's sales territories have included Baltimore, Washington and Virginia.

FISCHER & PORTER CO., has promoted **Robert L. Rice** to general sales manager. Rice joined F & P in 1950 as a sales engineer, becoming sales manager of the Cincinnati office a year later. For the past three years he has been manager of the Water and Waste division, which manufactures and distributes chlorination equipment. **James Haskett** replaces Rice as manager of the division.

Rice graduated from the University of Cincinnati with a B.S. degree in mechanical engineering. He is a member of the Instrument Society of America, the American Society of Mechanical Engineers, the American Water Works Association and the Federation of Sewage and Industrial Waste Association.

OKONITE CO., has appointed **Dewey A. White** and **J. G. Wicks** as regional sales managers.

White, district manager of the company's Birmingham district since 1941, will now supervise the activities of the Birmingham, New Orleans and Dallas districts. The Philadelphia, Boston, Cincinnati, Syracuse, Detroit, Cleveland and

Free to PETROLEUM REFINER Subscribers

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REGENERATES IN SITU!

THIS IS THE CATALYST

Sinclair-BAKER RD 150
Platinum Reforming Catalyst

THESE ARE THE REASONS WHY

BAKER'S RD 150 continues to prove the most efficient of all reforming catalysts—producing important yield increases at high octane levels and high octane reformates from low grade naphthas.

The long period of initial operation is unmatched by any other catalyst . . . and beyond that, *RD 150 is regenerative in situ!* Cost is sharply reduced to lowest level.

RD 150, a joint development of Baker & Co., Inc. and Sinclair Research Laboratories is unique. It is being used in highly successful production by many producers in this country and abroad. A Baker representative will be glad to give you detailed information, upon request.

All data of confidential nature are of course treated accordingly.

BAKER & COMPANY, INC. CATALYSTS

BAKER & CO., INC.
113 ASTOR STREET, NEWARK 5, NEW JERSEY
NEW YORK • SAN FRANCISCO • LOS ANGELES • CHICAGO
ENGELHARD INDUSTRIES

SEND FOR BROCHURE
The Role Of Platinum Group Metals As Catalysts

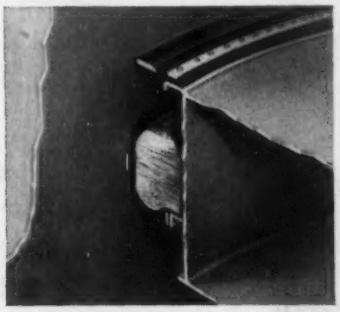
THE HUB OF PLATINUM METALS RESEARCH

every oil operator wants to know

HOW TO PREVENT LIGHTNING FIRES IN TANKS

the answer is now available

USE HAMMOND TUBESEAL* FLOATING ROOFS!

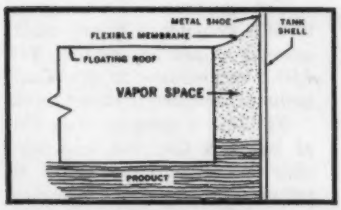


TUBESEALS are made lightning-proof with their exclusive electric conductor weather seal.[1] This specially compounded synthetic rubber, extending continuously around the entire perimeter, between roof and tank shell, provides an infinite number of contact points. ELABORATE TESTING by an independent laboratory[2] discloses that the seal prevents isolation and collection of static electricity charges, providing a continuous conductive surface with large current carrying capacity. Induced charges from lightning are immediately dissipated and fires are prevented. There are no mechanical contacts to cause sparking.

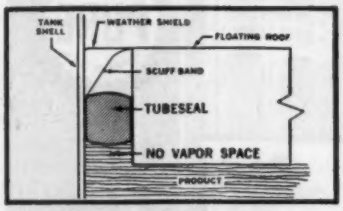
WITHOUT VAPOR THERE CAN BE NO FIRES **. . . the inherent design and construction of Hammond Tubeseals eliminates space between roof, shell, and liquid; thus, there is no room for vapor to form . . . no vapor . . . no fires . . . no evaporation . . . no corrosion!**

Introduced to the oil industry late in 1955, the Hammond Tubeseal found immediate favor with oil companies all over the world . . . there are now more than 200 installations in operation and building. A measure of their conservation values and fireproof features is illustrated by their record of repeat orders from satisfied users—one large oil company, after several test installations, re-ordered more than a score of Tubeseals. The same story of satisfaction exists wherever a Tubeseal is in operation.

Write for bulletin TS



CONVENTIONAL FLOATING ROOF tank has space below flexible membrane where air-vapor mixtures form. Because metal shoe and membrane cannot be absolutely gas tight, vapor is constantly escaping. This condition causes excessive corrosion, may also result in rim fires from lightning or other source.



HAMMOND TUBESEAL FLOATING ROOF entirely eliminates every space where air-vapor mixtures can form. Hammond Tubeseal completely fills space between product surface and roof seal, so that corrosion is stopped (even for sour crudes), and vapor cannot form—hence cannot ignite or be lost.

THE HAMMOND TUBESEAL
for new or old floating roof tanks,

FEATURES

- **lightning and fire proof construction**
- **no moving parts**
- **no mechanical maintenance**
- **climate-proof**
- **non-corrodible**
- **can operate to bottom of tank or above the top**
- **no vapor space below the seal**
- **entire circumference has tight seal under pressure at all times**
- **longer working life expectancy**

*Patented [1]patent pending [2]names on request

HAMMOND TUBESEAL — THE MOST EFFICIENT AND POSITIVE SEAL KNOWN

HAMMOND IRON WORKS

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales Offices:

NEWARK 2, N. J. • BOSTON 10, MASS. • BRIDGEPORT, CONN. • CINCINNATI 2, OHIO • CHICAGO 3, ILL. WARREN, PA. • BRISTOL, PA. • ARLINGTON, VA. • GREENVILLE, S. C. • BIRMINGHAM, ALA. SAPULPA, OKLA. • PROVO, UTAH • CASPER, WYO. • LOS ANGELES 57, CALIF. • HAVANA • MEXICO CITY "TIPSA," BUENOS AIRES • CAIRO, EGYPT • PORT-AU-PRINCE, HAITI • LIMA, PERU

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Suppliers . . .

Pittsburgh offices will report to Wicks, who has been Philadelphia district manager since 1954. Both men will work closely with **I. W. Borda**, recently named vice president and general sales manager.

White received his education at Georgia Institute of Technology. He is a member of the American Institute of Electrical Engineers and the Sales Executives Club in Birmingham.

Wicks, who joined the field sales force at the Philadelphia office in 1942, is a member of the Association of Iron and Steel Engineers, the International Municipal Signal Engineers and the American Institute of Electrical Engineers.

WALWORTH CO. has named **Milford H. Luttrell** general sales manager of the company. Luttrell joined Walworth in 1933. He was appointed assistant manager of the Southeastern division in 1944 and made manager in 1949.

He lives with his wife, the former Margaret Ellis, at 101 Greenwood Place, Decatur, Ga. They have two children, John Frederic and Margaret Ann.

LONGHORN SUPPLY CO., Houston, has been appointed Houston area distributor for **Enardo Manufacturing Co.**, Tulsa. Longhorn will stock a full line of Enardo equipment, which includes valves, fittings and other oil field specialty items.

JEFFERSON CHEMICAL CO., has named **R. M. Roach** New York district sales manager it was announced by **Donald L. Griswold**, general manager of the company's Marketing department. **R. J. Robinson** is being transferred from Cleveland to the New York Office and **J. M. Luger** is moving from Houston to Cleveland to take over the territory previously handled by Robinson.

Roach is a graduate of Villanova University, where he received his B.S. degree in chemical engineering. He joined Jefferson's New York sales staff in 1953, and replaces **George H. Kahl**, who has resigned.

Robinson, a chemical engineering grad-

Be Sure To Check This Month's Classified Section in REFINER

Need Engineers - Technical Personnel? Try a Classified Ad in Petroleum REFINER.

QUICK! ECONOMICAL! RESULTFUL!

Help Wanted! Classified Ads in Petroleum REFINER get the job done.

PEABODY *delivers more!*

- **Compact**
  - Minimum diameter due to maximum free space velocity
  - Minimum height due to maximum efficiency with few contact stages
- **Efficient**
  - Intimate gas-liquid contact
  - High heat transfer rate
  - Close terminal temperatures
  - Maximum cooling effect
  - High absorption rate
  - Maximum cleaning effect
  - Flat performance curve
- **Economical**
  - Low liquid consumption
  - Low liquid pressure
  - Low gas pressure loss
- **Flexible**
  - Pressure—1 p.s.i.a. to 465 p.s.i.a.
  - Temperature—to 3500° F.
  - Capacity—100 to 200,000 C.F.M.
  - Installation—vertical or horizontal
  - Material—steel, lead, plastic
- **Adaptable**
  - Various process cycles
  - Clear liquids or slurries
  - Corrosive or non-corrosive fluids

PEABODY ENGINEERING CORPORATION

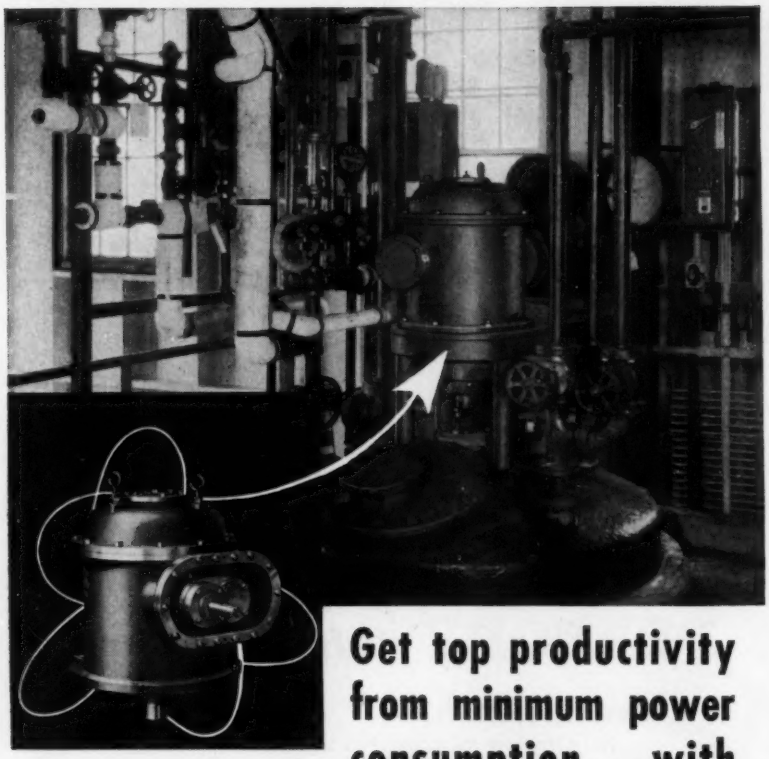
232 MADISON AVENUE, NEW YORK 16, N.Y.

OFFICES IN PRINCIPAL CITIES

PEABODY LIMITED • LONDON, S.W. 1, ENGLAND

7-120

For more data on advertised products, use Readers' Service Cards, last page.



Get top productivity from minimum power consumption . . . with NETTCO "Engineered" Agitation!!

The agitator should suit the application . . . or unsatisfactory agitation, high power costs, and excessive maintenance may result. Exact process specifications can be met by providing the right combination of motor, drive, shaft, and stirrer. Nettco's ability to provide these standardized components . . . in the right size, the right speed, the right horsepower, etc. . . . mean savings and dependable, uninterrupted service to you. Check the design features of the Model T agitator line, and see what over fifty years experience . . . in producing the most complete agitator line available . . . offers you.

- **Minimum moving parts in compact, fully enclosed housing**
- **Interchangeable ratios from 6.25:1 to 100:1**
- **Dust, fume, and moisture-proof.**
- **Complete range of speeds**
- **Anti-friction bearings throughout, quiet operation**
- **Splash lubrication — oil trapped against leakage**
- **Large diameter "stepped" vertical shaft**
- **Widely spaced, oversized Timken bearings**

Model WT units, featuring worm gear reduction drives, offer ratios from 3.5:1 to 68:1 — plus many modifications to suit application needs. Send your process specifications to NETTCO agitation engineers for recommendations . . . Request Bulletin 551 and data sheet from **New England Tank & Tower Co., 81 Tileston St., Everett 49, Mass.**

NETTCO

FREE LITERATURE

Please send me the following literature:

- ☐ **Tank Top Agitators—Bulletin 551**
- ☐ **Portable & Tripod Mixers—Spec. Sheets**
- ☐ **Pipeline-Flomix®—Bulletin 531**
- ☐ **Side Entering—Bulletin 532**

Suppliers . . .

uate of Case Institute, has been resident salesman in Jefferson's Cleveland office and Luger, who holds a chemical engineering degree from the Massachusetts Institute of Technology and an M.A. degree from Harvard, has been on the sales staff at the company's Houston office.

HAMAR VALVES, INC., has announced the appointment of two new sales representatives, the **Henry Kalz Co.**, Portland, Ore., and **Barber Machinery, Ltd.**, Calgary, Alberta, Canada.

Both firms, well known in their respective territories, will provide sales engineering assistance on the complete line of Hamer products. Territories for the Henry Kalz Co. include the state of Oregon while Barber Machinery will represent the Hamer line in the Canadian provinces of Saskatchewan, Alberta and the Peace River District of British Columbia.

TRACERLAB, INC., has announced the opening of a new sales office in St. Louis, Mo., at 7122 Jamieson Ave.

In charge of this new office for Tracerlab will be **John Eills**, formerly of Boston, Mass., and a graduate of Harvard College and Harvard Business School. Eills spent several years with headquarters sales in Waltham where he worked with all aspects of nuclear products development.

This new Tracerlab office will serve Tracerlab's customers in southern Illinois, southern Indiana, western Kentucky, western Tennessee, Iowa, Missouri, Nebraska, and Kansas.

HOOKER ELECTROCHEMICAL CO., Niagara Falls, N. Y., opened a new district sales office at 6 Penn Center Plaza, Philadelphia 3, Pa., on July 1. **Neil M. Barber** is manager—Philadelphia district sales, while **John J. Wojnar** has been named the new office manager.

The office will be headquarters for chemical sales representatives **Julian J. Boyce**, Charlotte, N. C.; **Joseph J. Lenahan**, Pittsburgh, and **Charles H. Foster, Jr.**, who will move shortly from New York City to the Philadelphia area. The office will also be headquarters for Durez Plastics division representatives **Robert W. Bainbridge, Michael G. Dubenitz** and **Alexander L. Blackwell.**

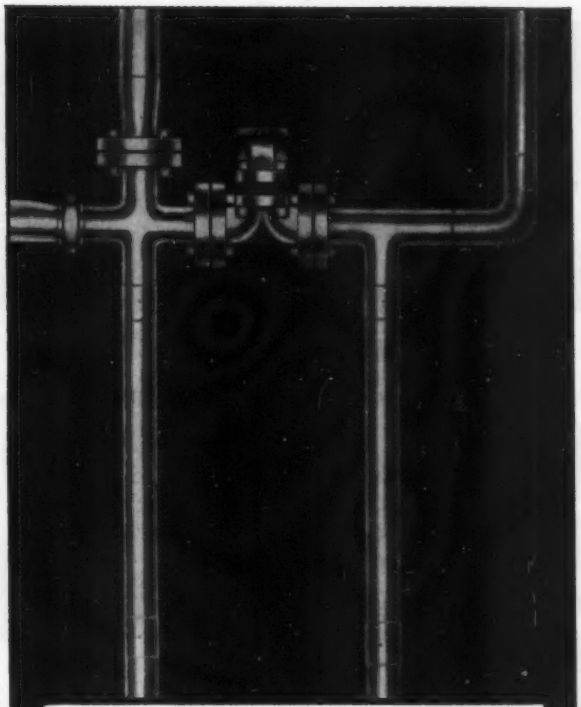
ZONOLITE CO., Chicago miners and manufacturers of vermiculite, has announced the appointment of Gunite Concrete and Construction Co., of Kansas City, Mo., as authorized applicators for its Blo-Crete industrial fireproofing, encasement, and protective coating systems.

Blo-Crete is the name given to machine-placed combinations of vermiculite and portland cement for industrial applica-

REFINER

Classified Ads Bring

RESULTS



PIPELINE ECONOMY
BEGINS AT THE FITTINGS!

Only *Speedline* Corrosion-Resistant Fittings permit

- Multiple choice of joint with *every* fitting—*on the job!*
- Time and cost saving design and assembly for *any* piping installation!
- Use of *low cost*, light wall Schedules 5 and 10 stainless pipe!

"Speedline Catalog" describes important cost saving advantages for *your* application. Request a copy at no obligation.

SPEEDLINE IS A REG. T.M. OF HORACE T. POTTS COMPANY

Speedline

104

STAINLESS STEEL FITTINGS

THE NEWEST THING IN PIPELINE ECONOMY

SPEEDLINE DISTRIBUTORS ARE LOCATED IN PRINCIPAL CITIES FROM COAST TO COAST

Manufactured by **HORACE T. POTTS COMPANY**
566 E. Erie Avenue • Philadelphia 34, Penna.

The stoutest pipe vise .... with built-in folding legs and tray

RIDGID
Tristand Pipe Vise

RIDGID Tristand Pipe Vise, yoke model.

Chain model also available.

Extra easy to fold up, carry and set up... Extra strong, extra rigid in use

Most service and durability for your money! Integral legs and tray mean quick easy fold-up for carrying and set-up for work—provide solid stance, greater strength.

Vise base is roomy, has ceiling brace screw, pipe benders, slots for tools. Special LonGrip jaws grip tight without chewing up pipe. Save work —see it, try it, buy it at your Supply House.

The Ridge Tool Company, Elyria, Ohio, U.S.A.

RIDGID
Work-Saver Pipe Tools

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

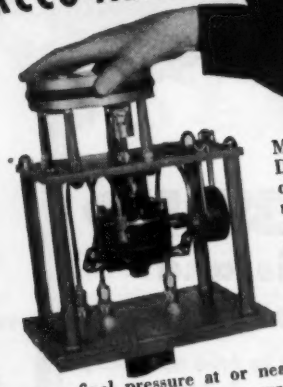
tion. Gunite Concrete and Construction Co., which operates twenty-one crews in various areas throughout the United States, is particularly known for its work in the petroleum refining industry, where a substantial part of the need for its services exists.

The announcement was made jointly by **R. W. Sterrett,** vice president-marketing, Zonolite Co., and **Barclay A. Greene,** president of Gunite Concrete and Construction Co.

Cosasco's enlarged El Monte, Calif., division.

ARCCO

ARCCO-Anubis CONTINUOUS GAS SAMPLER



MEETING THE DEMAND for more accurate gas sampling, this newly perfected ARCCO-Anubis instrument replaces inadequate, inaccurate spot sampling methods. The Model 100-7 will over a period of seven days accumulate at a constant rate a sample of gas to a final pressure at or near 100 psig from a sample source, the minimum pressure of which is not less than 125 psig.

The ARCCO-Anubis design is based on the principle that maintenance of a constant rate of increase in gas pressure within a closed container, from zero to any selected maximum pressure, will result in a continuous rate of flow of gas into the closed container.

This is accomplished by means of a specially designed regulation system equipped with a precision drive mechanism so as to obtain a constant predetermined rate of increase in the outlet pressure into the sample container.

Send for Bulletin No. 112

AVAILABLE FOR EARLY DELIVERY

AMERICAN RECORDING CHART CO.
3113 E. 11th St. Los Angeles 23, Calif.

Send for Bulletin No. 112-R1

Jay P. Gould

D. M. Etter

COSASCO DIVISION OF PERFECT CIRCLE CORPORATION, manufacturers of "Access" fittings and "Unitized" wellheads, has announced moving into new headquarters at 11655 McBean Drive, El Monte, California. The new plant has four times the floor space of the former location in LaCanada and is more convenient to transportation and related industries.

L. Auer

Key personnel of the Cosasco Division are Jay P. Gould, general manager of Cosasco and founder of the predecessor company, Corona Oil Specialties and Service Co.; D. M. Etter, sales manager and Leland Auer, manager of engineering.

The Cosasco Division was formed on June 5 last year when Perfect Circle Corporation, piston ring manufacturers of Hagerstown, Indiana, acquired the company. Products of the division include special nipples which permit entering lines and vessels against pressure, mandrels or tubing hangers, wet plugs and "Unitized" wellheads for wells, various corrosion-control accessories such as coupon holders, water samplers, thermo-couples and hydrogen probes for insertion through the nipples against pressure, and "Retrievers" (lubricators) with which to manipulate insertion or removal of plugs and accessories against pressure.

BENTLEY CHEMICAL CORP., 224 North Canon Dr., Beverly Hills, Calif., has been appointed as a distributor by Nitrogen division, Allied Chemical & Dye Corp. to handle sales of its ethanolamines in Los Angeles and Southern California.

Bentley Chemical Corp. will maintain stocks in Los Angeles.

For more data on advertised products, use Readers' Service Cards, last page.

PETROLEUM REFINER Classified Ads

Petroleum Refiner New Classified Rates

RATES: **Regular Classified** (undisplayed) set in this size type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border, $12.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * * *

HELP WANTED

CHEMICAL ENGINEERS
PROCESS ENGINEERING

Young men with advanced degrees in chemical engineering or at least three years' experience in process design of oil refining or chemical manufacturing facilities. Opportunities directly concerned with evaluation of research projects in the petroleum and chemical fields and design of new process units for Shell Oil Company and Shell Chemical Corporation. Located in the San Francisco Bay Area. Write giving education, experience, and personal history to Employment Supervisor.

SHELL DEVELOPMENT COMPANY
Emeryville 8, California

HELP WANTED

WANTED
REFINERY ENGINEERS

OUTSTANDING OPPORTUNITY FOR GRADUATE, MAINTENANCE AND PROCESS ENGINEERS WITH 4-8 YEARS EXPERIENCE.

This well-known independent oil company offers you an outstanding opportunity to grow with their refinery technological division.

Write giving academic qualifications and employment history, Mr. G. E. Smalley, Hancock Oil Company, P. O. Box 810, Long Beach 1, California.

MANUFACTURER'S AGENT WANTED

Manufacturers' agent required. Must have first rate connections with tube purchasers in:

ADMIRALTY.
AL-BRASS, CUPRONICKEL.

to act as U. S. representative competitive major English company. Project requires real fireball: knowledge import procedure advantageous. Mail confidentially Box 276-R, Petroleum Refiner, Houston, Texas.

FOR SALE

REFINERY EQUIPMENT

20-Million BTU free compartment furnace, complete with stack, 4″ x 5″ x 30 ft., 5 and 7% chrome tubes. Furnace is near new condition.

6 x 37 ft. vacuum towers, stabilizer towers and other refinery equipment available for immediate delivery. Inquiries are to be addressed to:

CECO Service Company, Denver Colorado
Telephone EMpire 4-2557
or P. O. Box 65, Aurora, Colorado
or P. O. Box 516, Phillips, Texas

CHALLENGING POSITION

We have challenging, responsible supervisory position open in our asphalt research program. Applicant must have considerable experience and background in the formulation and evaluation of asphalt specialty products, supervisory ability, and suitable academic background. Will also assist in technical sales development program. Salary open. Write giving qualifications to: Emmett R. Coley, Supervisor, Technical Recruitment, Lion Oil Company Division Monsanto Chemical Company, El Dorado, Arkansas

■ ASSISTANT Refinery Superintendent, chemical engineer with 13 years experience covering design, process calculations, construction, maintenance and operations. Just returned from Venezuela. Desire a position with petroleum or petrochemical company in the states. Box 275-R, PETROLEUM REFINER, Houston, Texas.

TECHNICAL ANALYST-WRITER

Broad-range job of technical writing and editing, including brochures, press releases, technical papers, reports, and monthly summary of petroleum-refining developments for high-level outside circulation. Desire engineer or chemist with knowledge of petroleum-refining and petrochemicals fields, plus prior writing experience. For more particulars send name and address to:

Personnel Manager
ETHYL CORPORATION
1600 W. Eight Mile Road
Ferndale 20, Detroit, Michigan

DESIGN ENGINEERS
SALES ENGINEERS
CHEMICAL ENGINEERS

Expanding activity in our UNION TANK & SUPPLY DIVISION brings unique opportunities to advance your career in the design and manufacture of oil and gas field production equipment. Nationally prominent manufacturer of diversified durable metal products. Experience with oil and gas equipment essential. Completion of formal engineering training needed. Salary in line with ability, training, and experience. Company-paid retirement plan; complete benefit program. Employment in Houston, Texas, one of the Southwest's most attractive cities. Send full information in confidential letter to ORVAL W. GROVES, Employment Supervisor, at address shown below. Interviews will be arranged in the early future.

Butler Manufacturing Co.
7400 East 13th Street
Kansas City 26, Missouri

Save on Your
INDUSTRIAL
TRACK
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FULLY
GUARANTEED
RELAYING RAILS
Handle more cars better—cost less to install and maintain. Foster stocks all Rail Sections 12# thru 175#, Switch Material and Track Accessories.
SEND FOR CATALOGS
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L B FOSTER CO.
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ATLANTA 8 • HOUSTON 2 • LOS ANGELES 5

REFINER Classified Ads Bring Results In A Hurry!

Titan Superjectors—continuous-type centrifuges—operate as long as a month without shutdown for cleaning. ASK FOR BULLETIN 946.

Pfaudler

Pfaudler Corrosioneering News Published by The Pfaudler Co., Rochester, N.Y.

How Bristol Laboratories makes glassed steel work harder in new product development

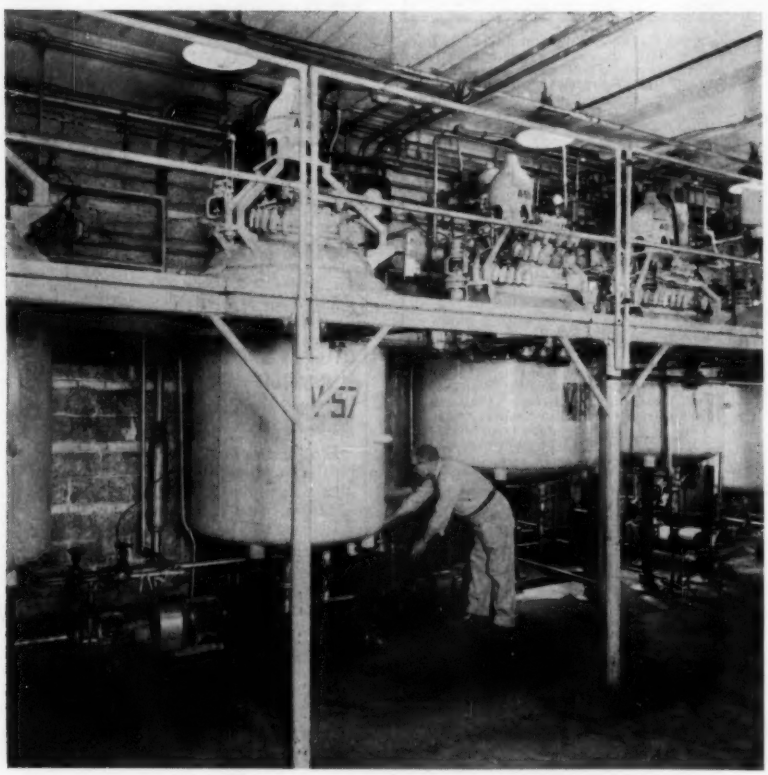
Any company faced with the combined problem of providing facilities that assure product purity while minimizing corrosion can profit from the experience of Bristol Laboratories, Syracuse, New York.

Research pilot plant procedures and quality control of production are all part of the routine of getting new products to market. Key link between research and production, of course, is the pilot plant. Long ago Bristol saw the necessity of having process equipment that is inert enough to permit handling most of the corrosives encountered, particularly HCl.

For example, the production of Polycycline, Bristol's trade name for tetracycline, involves several steps, including direct fermentation and acetylation. Corrosion is a serious problem in the latter step. It must be avoided or the product would become contaminated.

Pfaudler steam jacketed, glassed steel vessels solved this problem economically. Resistant to all acids, except HF, and all alkalies up to pH 12 at 212° F., it gave Bristol Labs better protection than any other material of construction. Because this glass is inert, there are no undesired side reactions. Adherence is no problem. This makes cleaning and maintenance easier and quicker. Changeover time is reduced to the minimum. Output is, therefore, greater.

These are some of the advantages you gain with Pfaudler glassed steel. It gives you the versatility you need in meeting today's highly competitive markets.



Glassed steel is tough, but...

It's not invincible. Simple common sense, care and attention account for the many, many pieces of glassed steel equipment that have provided 25 years and more of corrosion-free service.

Quick repairs to damaged areas also prolong the life of such equipment. These repairs are easy to make, require little special skill.

Preventive maintenance in installation and during operation is best, though.

Take knocks, for example. Soft sole shoes or heavy wool socks over shoes will save a glass lining from scratches during tank inspections. Securing tools to a belt helps too.

Take shocks. A simple, constant check of vessel and charge temperatures will protect linings from thermal shocks.

Take locks. There's a right way to draw up flange nuts. Once learned, you'll never have a cracked flange lining.

You can train all your men to understand and follow these and many other pointers by having them attend a Pfaudler Maintenance Seminar. This program is given at regular intervals at our own home plants and, when feasible, right in your own plant or locality.

The Pfaudler representative who contacts you can help.

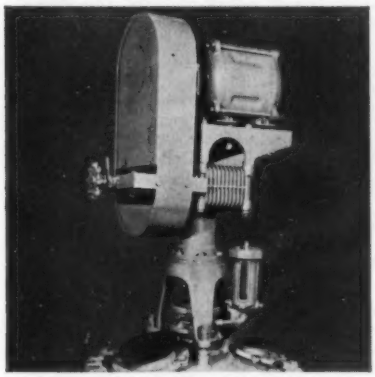
Still another source of information about the care and handling of glassed steel is to be found in our technical bulletins, such as No. 892—*The Surprising Structural Strength of Glass Fused to Steel.* A copy of this is yours if you'll simply mail us the coupon.

Corrosioneering News

Quick facts about services and equipment available to help you reduce corrosion and processing costs.

New, more compact drive... power is higher, agitation range wider

When you can increase the load carrying capacity of a drive without increasing its size, you get at least three extra advantages. You get a wider range of agitation speeds, a compact unit that leaves surrounding area more accessible, and you eliminate cumbersome supports.



This 2.5W Drive is equipped with stuffing box. Can also be used with rotary seal. Hydraulic drives of the new design are available for 100% explosion-proof construction and wide, variable speed range.

All this we have done with our new Type "W" Drives.

Carry greater loads. These new drives handle heavier loads than any other type of comparable worm gearing. They have what is called a "throated" design — both gear and worm teeth have convex arc shapes—which allows more teeth to mesh simultaneously.

More compact. Notice that the motor is mounted out of the way *above* the drive. This eliminates angular bracing from the top head, permitting a greater number of top head openings. These openings are more accessible and give great flexibility to top head layout . . . particularly valuable features on smaller reactors. (Side mounted motors are available where headroom is limited.)

Hydraulic, explosion-proof drives available. When you want 100% explosion-proof construction and wide variable-speed range, you can specify hydraulic drives. These can be supplied at the factory or substituted for existing drives in your plant, by converting with hydraulic motors.

The new drives can also be furnished with double reduction gearing and flange-mounted motor. This provides a totally enclosed gear drive with agitator speeds from 525 to 7.3 RPM in 27 increments.

Complete flexibility. You can use the new "W" Drives with stuffing box or mechanical seal on both glassed and stainless steel reactors.

Standard 2.5W, 3W, 4W, and 5W Drives are equipped with constant speed sheaves with static-free belts that can be combined to give any required speed for the agitation you desire.

Complete data on design and performance are in Bulletin 951. Check the coupon for a copy.

NEW SERVICE:

Customer advisory board reviews Pfaudler designs

The best way to give a customer what he wants is to ask him. Pfaudler did just that by inviting a representative group of management engineers from leading chemical processing plants to appraise design aspects of their standard equipment.

Particularly in the areas of plant hook-up, operation, and maintenance, the experience these men have derived from using our equipment complements nicely our design, manufacturing, and field service experience.

The first of the annual meetings of the board was held in May of this year and the commentary more than met our expectations. You will see tangible evidence of the Advisory Board's suggestions in our exhibit at the 26th Exposition of Chemical Industries (Dec. 2-6, New York City).

The Advisory Board is an extension of our continuing efforts to encourage intercommunication between our own personnel and customers. Pfaudler Corrosion Seminars and Maintenance Seminars are still other facets of this program.

We are, of course, always happy to receive your individual suggestions as to how we can serve you better.

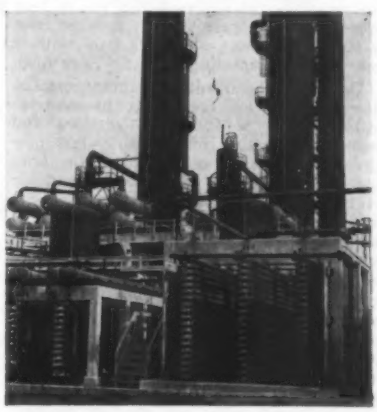
Glassed pipe, fittings, valves vital links in preventing corrosion

Getting materials to and from process equipment presents numerous areas of possible contamination and corrosion. This is why Pfaudler glassed pipe, fittings, and valves make worthwhile additions to your corrosion-free reactors, heat exchangers, columns, etc.

The glass in Pfaudler pipe, fittings, valves and accessory equipment is identical to that used on Pfaudler reactors and tanks—resistant to wide range of acid and alkali corrosion and economically justified.

The smooth surface of glass also minimizes friction, speeding up product movement. Cleaning is simplified.

Standard flanged glassed pipe and fittings are available in diameters from 1½" to 12" I.D. for temperatures up to 400° F. and 150 psi. Outlet, safety, diffuser and line valves will also handle a comparable range of temperatures and pressures.



Another way of using glassed pipe—jacketed and unjacketed—is in the form of heaters and coolers. Over 10,000 feet were used in making up these polymer heaters and coolers.

THE PFAUDLER CO., DEPT. PR-97, ROCHESTER 3, NEW YORK

Please send me information on ☐ Glassed Steel Reactors ☐ Bulletin 892—Structural Strength of Glassed Steel ☐ Bulletin 951—New "W" Drives ☐ Bulletin 886—Pipes, Fittings, Valves.

Name..... Title.....

Company.....

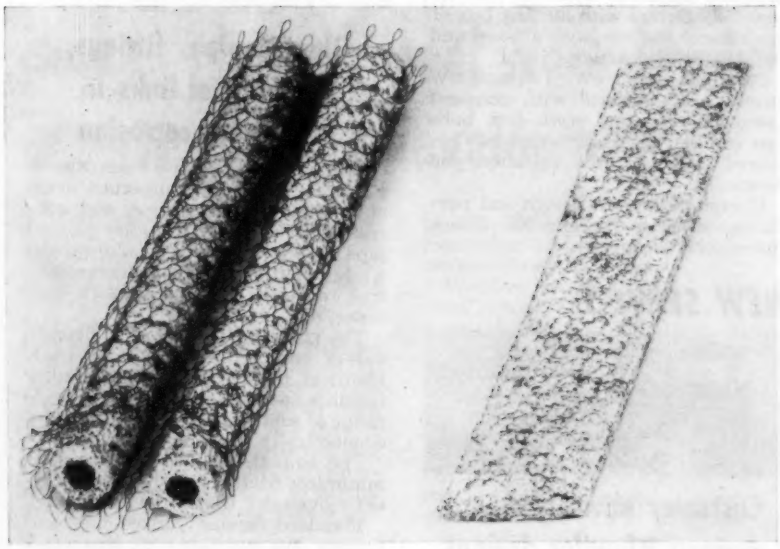
Address.....

City..... Zone..... State.....

For more data on advertised products, use Readers' Service Cards, last page.

What's New in Equipment . . .

. . . and Manufacturers Literature



New Gasketing Material Stops Tray Leaks

If you're faced with the problems resulting from excessive leakage across fractionating trays, it may pay you to look into an improvement that a large east coast refinery was able to attain with a new type of gasketing—Metex Tray Seal.

Designed specifically to meet installation and service conditions incident to sealing joints between tray sections and around the tray circumference, this new gasketing is made of pure asbestos fibre and Knitted Monel wire, and is available in two forms (see illustration). Conventional gasketing generally used for such installations is made of asbestos and cotton woven in tape form.

When conventional gasketing was used to seal these joints, it was difficult to keep water-test leakage to the desired minimum, even on new installations made at normal turn arounds. And after a year's run, leakage was often as high as 370 percent above allowable, with serious effects on production and product quality. Examination of trays showed excessive localized leakage at these joints. The conventional gasketing generally had to be replaced. It had not only lost its resiliency, but the cotton had become charred, leaving open spaces along the joints. General over-all leakage through risers and caps, while definitely present, was apparently not so serious a consideration.

A nine foot I.D. atmospheric tower in a crude oil pipe still was selected for the first installation of this new tray seal because it had been a particularly troublesome "leaker" with conventional gasketing. Operating temperatures of 200 F. with highly corrosive conditions literally "burned out" the cotton, resulting in excessive localized leakage at the end of a run—often 370 percent above allowable. Even after re-gasketing during turnarounds, leakage tests were often 20 percent to 30 percent above allowable. But since no other material was available, the tower was put back on-stream with the unsatisfactory year-end results mentioned above.

When the new Tray Seal was first installed, leakage tests show 6 percent under allowable, with no localized leakage. At the end of a year's run, total tray leakage had risen to only 67 percent above allowable, compared to the 370 percent previously experienced. Moreover, examination of the tray during tests showed that only 20 percent to 25 percent of this leakage was traceable to the gasketed joints. The Tray Seal showed no charring, was still resilient and was not replaced. Tightening of a few of the tray section bolts was the only attention required.

Not only has this new gasketing materially reduced tray leakage, but it has proved easier and quicker to install, particularly the Tray Seal, Dumbell type, designed for sealing joints between tray sections. Here the tray bolts are readily pushed through the Knitted wire sheath or envelope as the gasketing is laid in place. Time and labor required to locate and punch holes in the conventional gasketing tape has been entirely eliminated. Also Tray Seal has proved more resilient and compressible, thus permitting a tighter seal at all joints in spite of inevitable variations in the mating surfaces. Down time for testing has been materially reduced, and little if any retightening of bolts has been required. Metal Textile Corp.

Circle E1 green card, last page

Drafting and Calculating Shortcuts Shown in Booklet

This booklet shows 59 shortcuts to speed drafting and computation work.

Frederick Post Co., went to leading engineers and draftsmen and asked them what techniques they use to save time without sacrificing precision in their work. From the many interesting tips and drafting shortcuts suggested, a total of 59 have been compiled into one handy booklet called "Time Saving Tips for the Draftsman and Engineer."

Clearly written and well illustrated, this booklet shows new approaches to old problems. The section on Calculation Ideas contains ten tips including easy ways of "Remembering the Signs of Trig Functions," "Dividing a Circle Into Parts," and "Locating Decimal Points." Frederick Post Co. **Circle E2 green card, last page**

Tables Give ASTM and ASME Pipe Specifications

Engineers, designers, and layout men involved with steel piping will be interested in a data folder just issued. Two tables are shown in the folder. One table lists dimensional data for 16 sizes of pipe from ⅛-inch to eight inches nominal size for six different weight schedules showing O.D., I.D., wall thickness, and weights per foot. The other table covers ASTM, ASME Specifications, showing title, grade, type, and analysis for various carbon, alloy, and stainless steel pipe used for high temperature, high pressure and other services. The Babcock & Wilcox Co.

Circle E3 green card, last page

First Package Remote Valve Control System Available

The first package control system for remote positioning of cone, butterfly, plug and ball valves; sliding stem valves; such variable speed mechanisms as throttles and rheostats; and other final control elements, has just been developed.

The system can control pressure, flow,

Klingerit Gaskets

COST LESS

BECAUSE THEY LAST LONGER!

In modern Refineries and Chemical Plants the world over Klingerit Gaskets have proved their dependability and economy by keeping the highest temperature and pressure joints tighter and trouble-free . . . LONGER.

For use on steam, oils, gases, chemicals, spirits and solvents as well as compressed air—Klingerit Gaskets are available through conveniently located agents in principal cities. Thicknesses from .008 to ¼". Sheet sizes to 60" x 120".

"Klingerit"—Universally used sheet packing for superheated and saturated steam, hydraulic pressures, compressed air, gases, chemicals, oils, spirits and ammonia solvents.

"Klingerit 1000"—Wire reinforced sheet packing for extremely high temperatures and pressures. Specially suitable for cylinder head and exhaust joints in internal combustion engines, gas turbines, etc.

"Klinger-Acidit"—Acid resisting sheet packing, produced especially to resist hot nitric, hydrochloric and sulphuric acids, as well as most other organic and inorganic acids.

"Klinger-Oilit"—Oil resistant sheet packing intended for use in oil refining and distributing as well as for use with methyl-chloride and sulphur dioxide.

RICHARD KLINGER INC. 550, FOURTH AVENUE, BROOKLYN 15, NEW YORK
SOUTH 8-6747

Manufacturing Licensees for Canada
JOSEPH ROBB & COMPANY LIMITED, 5575, COTE ST. PAUL ROAD, MONTREAL, 20, CANADA
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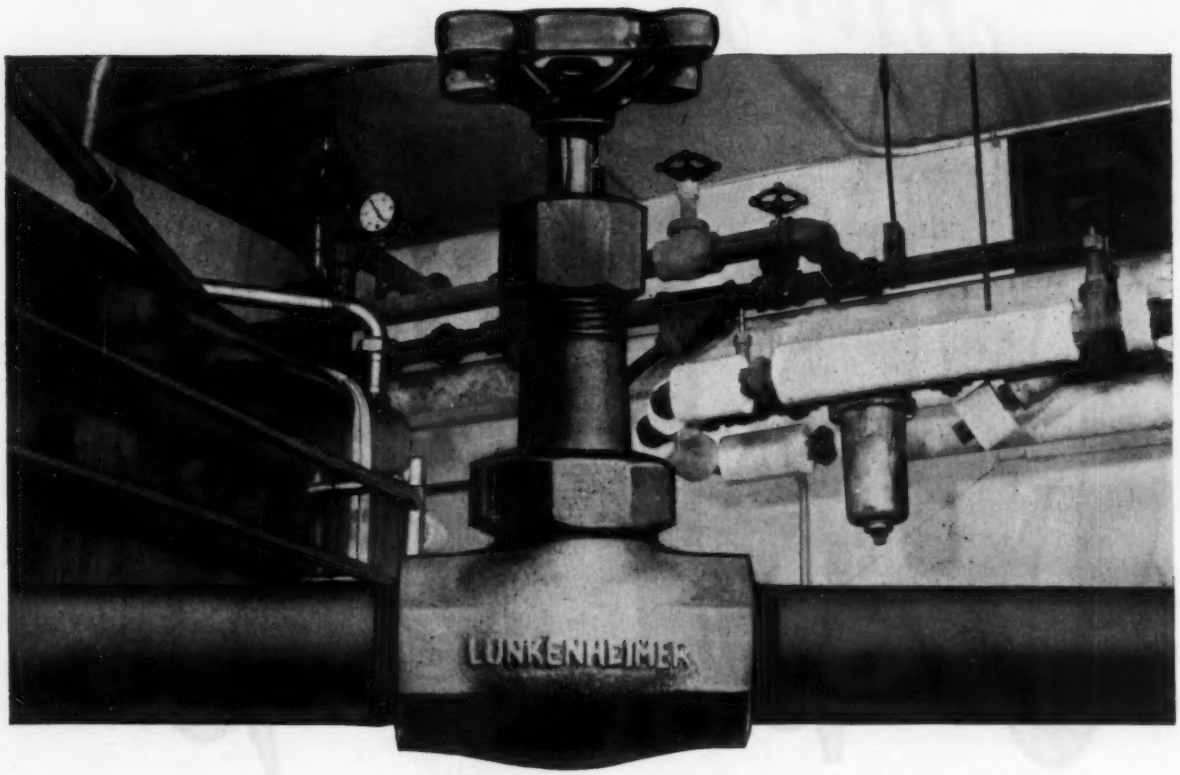
GA32/57/1

ONE ANSWER
to spiraling maintenance costs



LQ600—The Most Maintenance-Free Bronze Globe Valve Ever Developed!

The moment a maintenance man touches a wrench to a valve, its cost can double. You can't bring down that labor expense in many plants, but you can buy valves with an outstanding record of trouble-free service. At no time in history has valve quality been so important to your total plant expense. And quality has been a tradition for nearly a hundred years at The Lunkenheimer Company, Box 360, Annex Station, Cincinnati 14, Ohio.

See your cost-reducing Lunkenheimer distributor . . . or write for literature.

BRONZE • IRON • STEEL • PVC

The cost of a LUNKENHEIMER VALVE
Gets smaller...and smaller...and smaller...
with each passing year of dependable service

L-757-9

LUNKENHEIMER QUALITY

LUNKENHEIMER®
THE ONE *Great* NAME IN VALVES

New Equipment . . .

surge, liquid level, proportioning, speed, and other process variables at distances of a few feet to many miles with one operator at one central location.

The entire system, which combines the response speed of electronics with the smoothness of pneumatics and hydraulics, utilizes a power supply, positioner, reducing valves and booster valve as standard components in a single compact package, which receives its signals from the remotely located supervisory control unit via telegraph, telephone or private wires, or microwave transmission. A. W. Cash Co.

Circle E4 green card, last page

Chemical Eyeshield Has Extra Ventilating Area

By using an original design Vinyl hood 11¾-inch long with 78 staggered ventilating baffles, more than twice the ventilation normally possible with the old style round hooded vents, is achieved in the new concept "Airflow Chem." Splashes, dust and other foreign particles are further "screened out" by a wrap-around integrally molded stainless steel 20 mesh screen. This generous screen ventilation permits air to flow freely to eliminate hazardous fogging.

Unusually comfortable . . . the "Airflow Chem" weighs only 3 ounces. The frame of soft, flexible vinyl has rolled edges that mold to the natural contours of different faces. Extra comfort is provided by the soft vinyl integral nose pad which is flared for a more comfortable, snug fit for different nose shapes. The "Airflow" fits everyone, including those wearing personal eyewear with the widest type frames.

Full vision downward to the normal work level is possible by a design which tilts the lens in toward the cheekbones. This gives the correct pantascopic angle just as in personal glasses. United States Safety Service Co.

Circle E5 green card, last page

Pre-Cured Tank Lining Described in Bulletin

A technical bulletin describing properties of "Fairprene" T-5594 synthetic elastomer pre-vulcanized protective lining is now available.

The illustrated, eight-page booklet sets forth in chart form chemical resistance results obtained from immersion tests. Data are also included on "Fairprene" cements and putties used in fabricating liners from this unusual, pre-cured isobutylene material. Offering definite advantages over natural rubber, both in chemical properties

Panalarm Annunciator pinpoints process "off-normals"

In the process industries and among users of automatic machinery, trouble is minimized when it's caught early. That's the purpose of the Panalarm Annunciator System—a continuous monitor of your process.

One typical adaptation of the modular Panalarm system is engineered to differentiate between the first "off-normal" and subsequent "off-normals" caused by the first. This feature allows instantaneous recognition of the prime source of trouble in a "chain reaction."

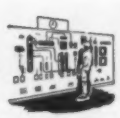
Another adaptation is designed specifically for motor start-up and shutdown. It has also been successfully adapted for supervisory control, pump control and programming.

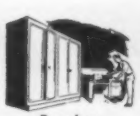
Your Panalarm sales engineer will be happy to make a survey of your requirements to determine whether a Panalarm system can aid productivity and safety in your process. For electrical and mechanical data on standard systems, request Catalog 100B on your letterhead.

PANALARM

Division of
PANELLIT, INC.
7415 N. Hamlin Avenue, Skokie, Illinois
Panellit of Canada, Ltd., Toronto 14

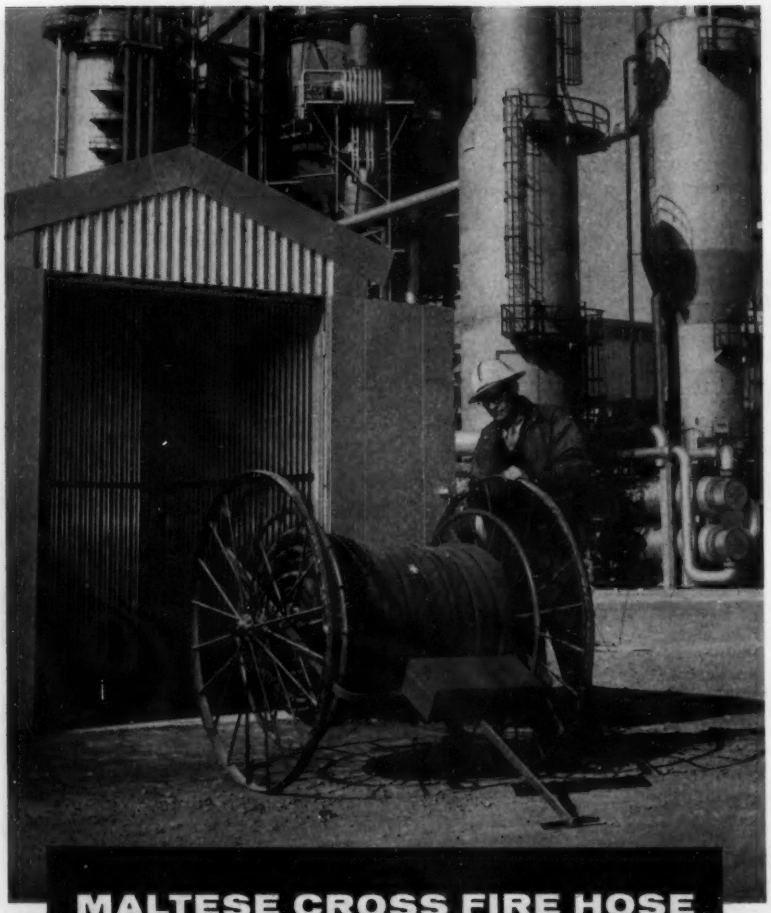
Engineered Information Systems for Industry


Graphic Panels, Control Centers


Panalog Information Systems

Panellit Service Corporation

For more data on advertised products, use Readers' Service Cards, last page.



MALTESE CROSS FIRE HOSE GIVES GREATER SAFETY, LASTS FIVE TIMES LONGER

Because it lasts five times longer than ordinary fire hose, Maltese Cross proved the most economical choice for the Tidewater Oil Company refinery near Wilmington, Delaware. It averages fifteen to twenty years' life in refinery service. Other benefits for Tidewater are Maltese Cross' 10 to 35 times greater fire resistance, and easier, safer handling for firemen.

The hose is placed on reels located at strategic points and is also carried on the refinery's fire trucks. Its neoprene cover makes it resistant to petroleum, mildew, and rot; and it is so constructed that it will not swing, writhe, twist, elongate, or contract under pressure. To find out how H-R products and services can help you, consult your classified telephone directory for the nearest H-R representative, or contact Hewitt-Robins, Stamford, Connecticut.

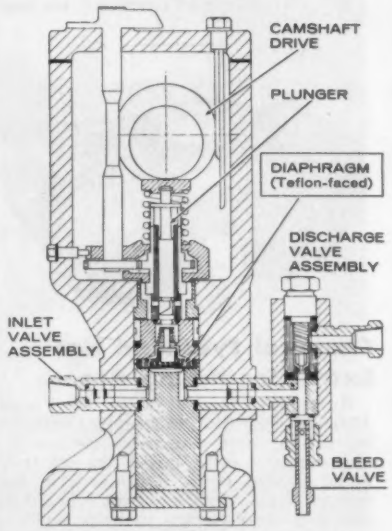
HR HEWITT-ROBINS

CONVEYOR BELTING AND IDLERS . . . POWER TRANSMISSION DRIVES
INDUSTRIAL HOSE . . . VIBRATING CONVEYORS, SCREENS & SHAKEOUTS

New Equipment . . .

and economy, "Fairprene" T-5594 makes field lining entirely practical, permits lining of objects too large for available ovens, eliminates refrigerated storage and shipping factors.

Although "Fairprene" can be installed at the site and requires no cure, the booklet points out that the work should be done by experienced personnel. Two pages of the bulletin are devoted to methods of installing "Fairprene" T-5594 protective lining sheet. E. I. du Pont de Nemours & Co. **Circle E6 green card, last page**



Packless Proportioning Pump With New Diaphragm

A new concept in packless diaphragm pumps for proportioning and metering fluids has just been developed. Thoroughly tested under actual operating conditions, this diaphragm pump performs with exceptional accuracy and minimum maintenance at pressures up to 2500 psi.

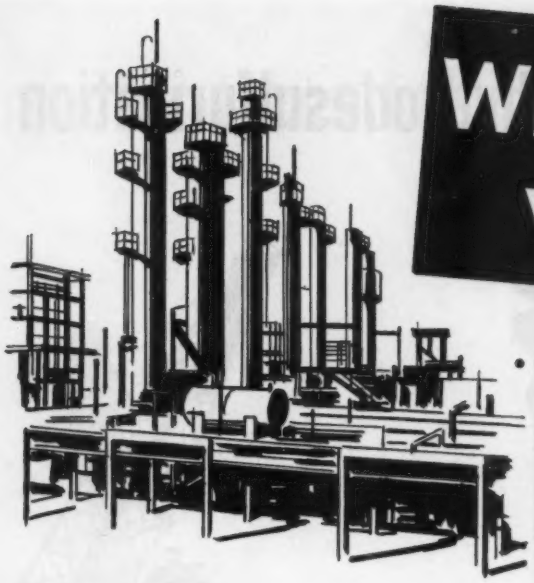
Its Teflon-faced diaphragm is a new development. It consists of solid Teflon permanently bonded to, and covering, the face of an elastomeric backing. This type of construction assures long diaphragm life by combining the chemical resistance of Teflon with the flexibility of an elastomeric backing. Hills-McCanna Co.

Circle E7 green card, last page

Interchangeable Pump Parts Reduce Inventory

Component interchangeability is stated as a major advantage of the refinery process pumps described in a new bulletin now available. Designated as type PR and type PRS, these pumps will handle virtually all liquids in refining processes including petroleum hydrocarbons, chemical solutions and water.

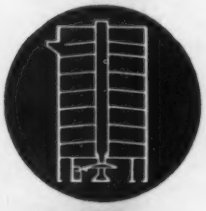
Said to be the most important aspect of the new line is component interchangeability. The Type PR pump is available in 14 sizes on three different frames; the type PRS is available in 12 sizes on three frames. The impellers and volutes on corresponding PR and PRS pumps are identical. It is claimed that this interchange-



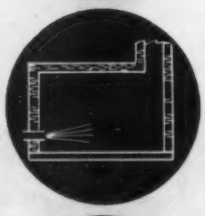
WHAT do you do with WASTES?

.. from Separators
Effluent Water Treatment
.. and Tank Bottoms
Acid Sludges
Spent Filter Clays
Plant Refuse
Soot Slurries

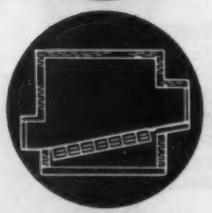
INCINERATION can provide needed STEAM



Multiple hearths for filter cake, sludges, etc.



Spray Chambers for liquids



Grate incinerators for industrial and municipal refuse

Fly ash eliminators

Yes, incineration in a custom-designed Nichols refinery wastes disposal unit can provide steam at no fuel cost while eliminating waste problems.

NICHOLS, well-known to petroleum refiners as builders of kilns for FILTER CLAY REGENERATION, offers long experience in the design and construction of many types of thermal processing and wastes disposal equipment.

Write for further information on the economic disposal of refinery wastes.

NICHOLS

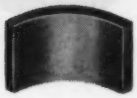
Engineering & Research Corp.

70 Pine St., New York, N. Y.

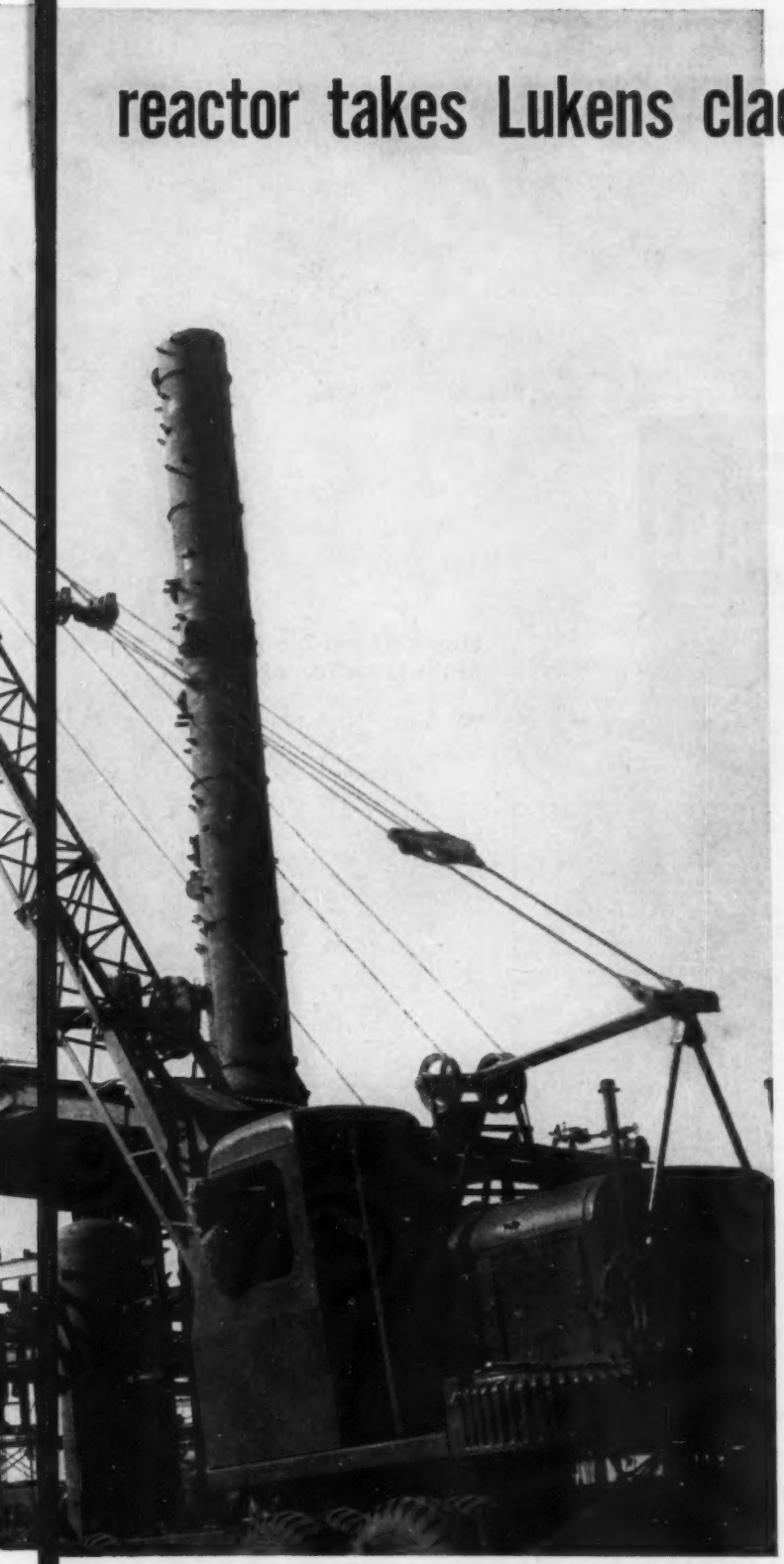
Indianapolis • San Francisco • Montreal

For more data on advertised products, use Readers' Service Cards, last page.

This is Lukens clad steel—not a lining, not a soldered-on surface, but a solid plate—one side corrosion resistant metal permanently bonded over-all to a rugged, economical backing steel.



reactor takes Lukens clad and alloy steels



CLAD STEEL STRIPPER, FLASH DRUM ALSO INSURE LONG-RUN ECONOMY, FREEDOM FROM MAINTENANCE

Designers and fabricators for Socony Mobil selected Lukens clad steel to combat corrosion by sulfur compounds . . . even at peak temperatures and pressures at which its new 22,000 bbl. catalytic hydrodesulfurization unit will operate at Paulsboro, N. J.

For the reactor vessel (left) and the top nine feet of the product stripper, Lukens stainless-clad type 321 was specified. ASME heads by Lukens are of the same materials —as is the flash drum.

Of equal importance, the backing of Lukens alloy—A-204 Gr. B carbon moly—resists the creep and hydrogen embrittlement which might otherwise result in this service. Typical temperatures range from 400° to 850°F., at pressures from 50 to 1500 psig. The installation is the first of many which Socony Mobil is planning for making No. 2 fuel oil a more efficient, better burning product.

It is another example of how Lukens clad and alloy steels provide maintenance-free corrosion protection at high temperatures and pressures.

Ask your equipment builders, or write for the new **Clad Steel Equipment** bulletin, as well as information on alloy steels. Address Manager, Marketing Service, Room 968, Lukens Steel Company, Coatesville, Pa.

LUKENS (R)

Helping industry choose steels that fit the job

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

ability will materially reduce the necessary spare parts inventory of the user.

General characteristics of the pumps provide capacities up to 1200 gpm, operating heads up to 700 feet. Temperature range of the type PR (packing gland construction) is up to 850 F.; temperature range of the type PRS (mechanical shaft seal construction) is up to 250 F. Case pressures are designed to 900 psi cold and 300 psi hot. Discharge sizes are 1 inch through 4 inches; a horizontal electric motor drive is standard. Peerless Pump Division, Food Machinery and Chemical Corp. **Circle E8 green card, last page**

244 Page Catalog Covers Complete Line of Valves

Just off the press is a complete new 244-page catalog covering Darling Gate Valves, Check Valves and Fire Hydrants in a broad range of types, sizes and constructions.

In addition to adequately covering the company's latest developments, such as the automatic, self-sealing, conduit gate valves, ball-bearing-operated dry-top hydrants and special-purpose corrosion-resistant valves, the new catalog No. 57 includes extensive engineering data, application tips, valve accessories information, and reference data on materials, specifications and standards. Darling Valve & Manuafcturing Co. **Circle E9 green card, last page**

Liquid Level Transmitter Mounts on Tank Nozzle

A new differential pressure liquid level transmitter mounts directly on a tank nozzle to provide a simple method for measuring viscous or slurry-type liquids in open or closed vessels.

The level measuring element—a silicone-filled diaphragm capsule—is assembled in a three-inch flange for flush mounting on the side of a vessel. Head of liquid in the vessel applies force to the high pressure side of the capsule which is opposed by force on the low pressure side. The low pressure side may be open to atmosphere for measurement of open tank level. Or it may be connected by piping to the top of a closed tank to balance out static pressure. Adjustable range suppression and elevation springs can be easily attached to accommodate the various installation arrangements.

The pneumatic output of the transmitter—a 3-15 psi signal proportional to tank level—will operate a remote indicator, recorder or controller. No auxiliary signal amplifier is needed. Purging systems are eliminated since viscous liquids are measured at tank side and not conducted through tubing. Wetted parts are type 316 stainless steel. The Foxboro Co.

Circle E10 green card, last page

Pipe and Fittings For High Temperatures

Engineers involved in the design, construction and operation of equipment involving the use of tubing and piping at elevated pressures and temperatures, will be interested in the up-to-date information contained in bulletins 145A and 152A just issued. Bulletin 145 discusses Croloy 2¼ (2¼ percent Cr, 1 percent Mo) and Bulletin 152 deals with B&W Croloy 1¼ (1¼ percent Cr, ½ percent Mo).

Tubing, pipe, welding fittings and flanges of these steels are widely used in refinery, petrochemical and steam services. The folders present technical data on analysis, mechanical and physical proper-

In Refractory Castables for the Refining Industry

WALSH has them ALL!

- Greater strength—better bond—throughout the complete temperature range.
- Maximum resistance to abrasion.
- "Iron-Free" (less than 1% iron content in Super Castable No. 32 & No. 50 NISF —to meet the needs of the petroleum refining industry.)

PRODUCT	MAXIMUM OPERATING TEMP.	WEIGHT DRY IN PLACE PER CU. FT.	FIRED CRUSHING STRENGTH (PSI)	
H & B Castable No. 8	2700° F.	128-130 lbs.	1100° F.—2000 1500° F.—1600 2000° F.—1900	WALSH H & B CASTABLES—Regular and Extra Strength—mix readily with water for casting, trowelling or air gunning. Form monolithic lining highly resistant to abrasion. Used for working linings in catalytic regenerators, reactors and other refinery equipment.
Extra Strength H & B Castable	2450° F.	128-130 lbs.	1100° F.—2200 1500° F.—1800 2000° F.—2100	
Castable No. 150	3400° F.	170-172 lbs.	1500° F.—7500 2550° F.—7600 3000° F.—8000	An hydraulic, "iron free" castable, producing highest resistance to abrasion at all temperatures.
Super Castable No. 32	3000° F.	130-134 lbs.	1500° F.—2900 2550° F.—3600 3000° F.—5000	Super Castable No. 32, an "iron free" castable, with excellent strengths at critical operating temperatures. Adheres readily where used as a patching material.
Lite Wate Castable No. 50	2100° F.	62-64 lbs.	600° F.—385 1500° F.—310 2000° F.—400	WALSH LITE WATE NO. 50 and 70, Insulating Castables. Can be readily trowelled and poured. Absolute minimum rebound loss when applied with air gun. Good strength with low heat conductivity—more than five times as resistant to heat flow than fire brick. Produce desired linings for flues and ducts, back-up linings for catalytic reactors and regenerators, and other refinery equipment.
Lite Wate Castable No. 70	2300° F.	80-82 lbs.	600° F.—500 1500° F.—450 2000° F.—1300	
Lite Wate Castable No. 50 NISF	2000° F.	51-53 lbs.	1000° F.—480 1500° F.—450	

Send for NEW CASTABLES BULLETIN

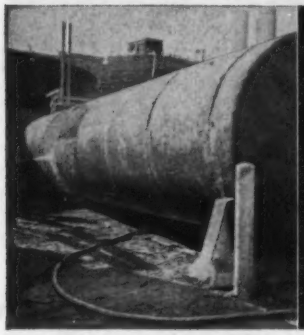
WALSH REFRACTORIES CORP.

101 Ferry Street • St. Louis 7, Missouri

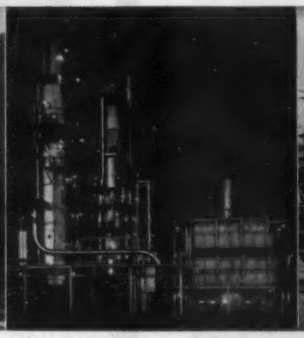
For over 60 years manufacturers of high grade refractories

new air placed Blo-crete®

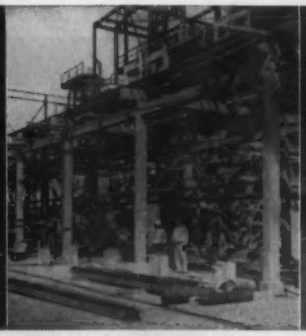
Makes Highly Efficient Fireproofing, Encasement and Protective Coatings...Quicker, Cleaner, at Reduced Cost



Fireproofing Gas Storage Tanks



Refinery Application



Stanchion Fireproofing

Fireproofing Vessel Skirts

BRINGS the Extra Benefits of Light Weight... Wide Applicability... A Prompt Job by Trained, Authorized Crews

Now, with Blo-crete, have the effective, lasting protective installations you want, with new speed, new economy!

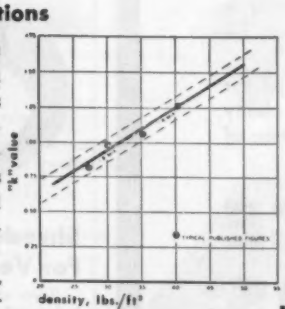
Blo-crete is a monolithic, stable, wet-gun-applied thermal coating, composed of the mineral vermiculite with suitable binders. It eliminates many costly and undesirable features of other materials and methods, and offers a combination of desirable features of its own.

Quick, Clean Installation

Trained, authorized applicators install Blo-crete with modern pneumatic wet-guns—the most practical of all techniques, especially for hard-to-get-at places—insuring a quick, clean, effective job.

High "K"—Many Applications

Your authorized Blo-crete applicator can offer you a wide variety of design mixes to meet any thermal or fireproofing requirement, as indicated in chart. Countless applications in industry and refining for this clean, efficient method.

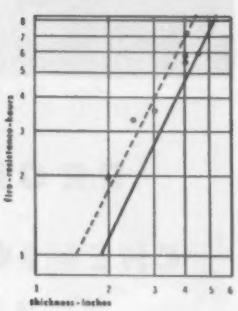


"K" factor, or insulating value, versus density of Blo-crete.

There's a qualified applicator near you to serve you. Mail coupon for his name, and data folder.

Affords High Fire Protection

Underwriters' Laboratories' fire tests on systems of construction using Blo-crete ingredients show material to be incombustible. Protect your investment, avoid treacherous fire with this unique fireproofing.



Results of U.L. fire tests on various thicknesses

Use BLO-CRETE on Your Next Job of

Refractory Lining... kilns, furnaces, stacks, breechings, ducts.

Fireproofing and Thermal Coating...tanks, vessels, towers, stanchions, pipe supports.

Steel Fireproofing...bonds directly to steel plate, members, walls, ceilings, floors.

Thermal Control in cold rooms.

Renovation of structures in refineries, and gasoline, oil, chemical and manufacturing plants.

For FREE Book on Blo-crete application in your business send this coupon now.

ZONOLITE CO., Industrial Fireproofing Div., Dept. PR-97
135 S. LaSalle St., Chicago 3, Ill.

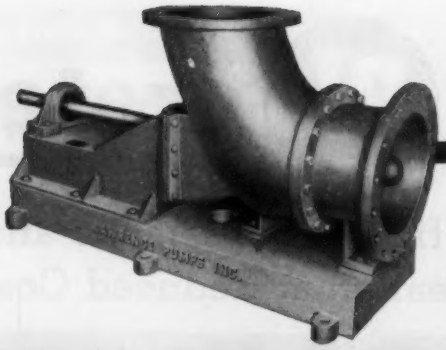
Send me Blo-crete data folder and name of my nearest applicator.

*Name, Title*_____

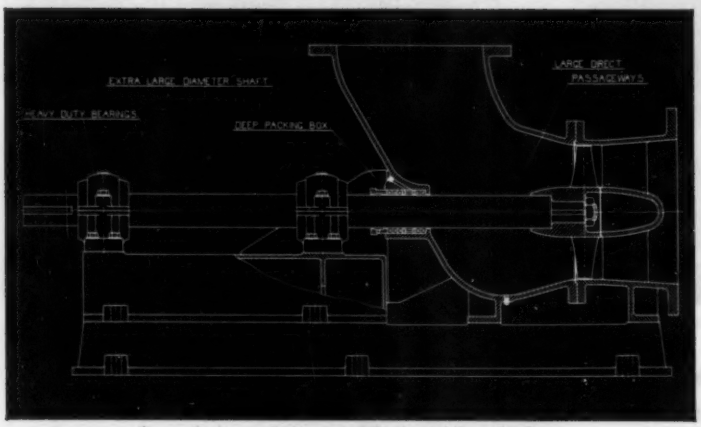
*Company*_____

*Address*_____

*City*_____ *Zone*____ *State*_____



Lawrence 24" Horizontal Circulating Pump of Nickel Alloy Construction



Cross Section of Lawrence Horizontal Propeller Pump

PROPELLER PUMPS FOR THE CHEMICAL and PROCESS INDUSTRIES

Lawrence Propeller or Axial Flow Pumps are widely used to circulate large volumes of liquid or slurry against low heads as in evaporators, crystallizers, etc. This type of pump is particularly well adapted for circulating service because of its simplicity, high efficiency, and low first cost. The flow can be arranged in either direction and the casing turned to any position desired to serve as an elbow. The capacity can be closely regulated by varying the speed—very important in crystallization processes where a uniform velocity must be maintained.

Lawrence Propeller Pumps are made of the metals and alloys best suited for their ability to resist the corrosive and abrasive action of the liquid pumped.

Write for Bulletin 203-7 for summary of acid and chemical pump data.

LAWRENCE PUMPS INC.

371 MARKET STREET, LAWRENCE, MASS.

New Equipment . . .

ties, fabrication, heat treatment and maximum allowable working pressures for various applications at different metal temperatures. The Babcock & Wilcox Co.

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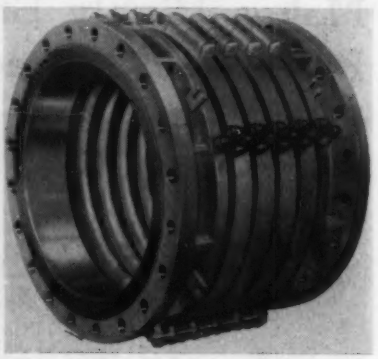
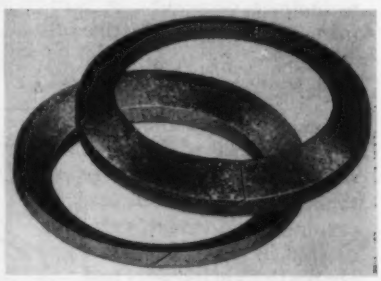


Expansion Joint Load Equalized With Pantograph

A line of improved corrugated expansion joints in which movement of power and process piping systems is shared equally by all corrugations is now available.

Equal distribution of pipe expansion and contraction to all of the corrugations is accomplished by pantographs, as shown in the figure. The pantograph neutrals are anchored to the unit's end fittings and intermediate equalizing rings. Any end fitting movement is immediately transferred by the pantograph to all equalizing rings. This moves all rings the same distance at the same time to give uniform use of all corrugations and prevent undue stress to any one corrugation.

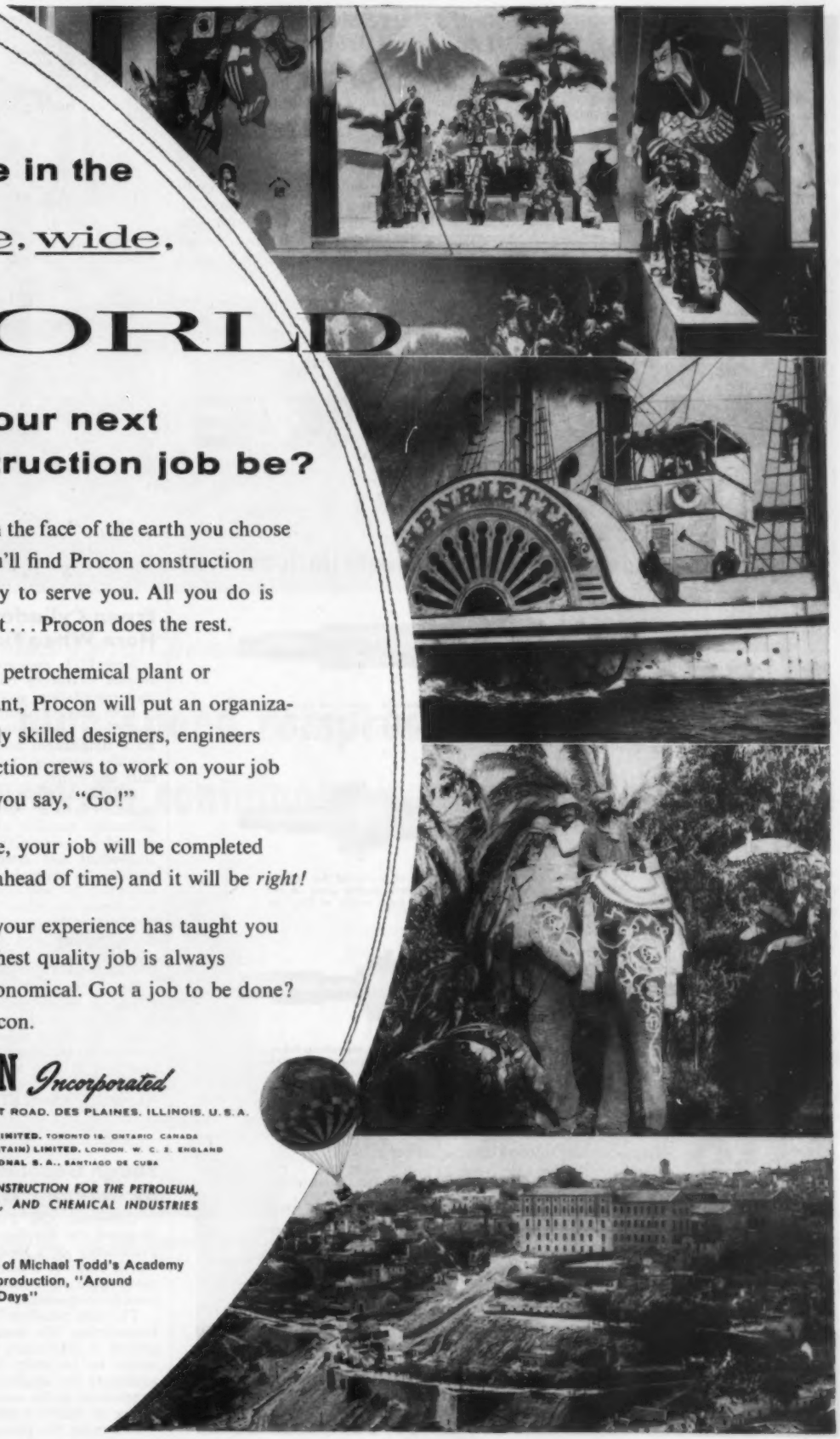
These new expansion joints feature four design improvements: (1) 40 percent longer life than self equalizing expansion joints at the same pressure and movement, (2) 30 percent less over-all length, (3) 30 percent less weight, and (4) greater stability at high pressures because of the reduced ratio of length to diameter. Zellea Brothers. **Circle E12 green card, last page**



Shredded Metal Packings For Very High Temperatures

Two shredded metal packings are now being offered for use under extremely high steam pressures and temperatures. Both styles are made of copper tinsel, treated with special rubber cements, graphited throughout, molded to shape and cut open with a beveled joint.

Style 934 is offered in ring form only,



where in the wide, wide, WORLD

will your next construction job be?

Wherever on the face of the earth you choose to build, you'll find Procon construction experts ready to serve you. All you do is pick the spot . . . Procon does the rest.

Oil refinery, petrochemical plant or chemical plant, Procon will put an organization of highly skilled designers, engineers and construction crews to work on your job the minute you say, "Go!"

What's more, your job will be completed on time (or ahead of time) and it will be *right!*

We're sure your experience has taught you that the highest quality job is always the most economical. Got a job to be done? Call on Procon.

PROCON *Incorporated*

1111 MT. PROSPECT ROAD, DES PLAINES, ILLINOIS, U. S. A.

PROCON (CANADA) LIMITED, TORONTO 18, ONTARIO, CANADA
PROCON (GREAT BRITAIN) LIMITED, LONDON, W. C. 2, ENGLAND
PROCON INTERNATIONAL S. A., SANTIAGO DE CUBA

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

Photos courtesy of Michael Todd's Academy Award winning production, "Around the World in 80 Days"

For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

usually molded to approximately a square cross section and bevel cut, while Style 935 is a packing set consisting of conical shaped molded center rings with 120 degree included angle and bronze top and bottom adapters. (See photograph).

Both styles are recommended against steam, air, water or gases (except ammonia) on valve stems, reciprocating rods, and rotary shafts of pumps, blowers, turbines, compressors and similar equipment. The Garlock Packing Co.

Circle E13 green card, last page

Ball Joints Solve Thermal Expansion Problems

How to handle thermal expansion and contraction in piping with ball joints is outlined in a new 6-page bulletin just published.

Illustrations of the four basic motion principles of Barco Ball Joints provide the key to the various examples of how to provide safe flexibility in service lines subject to severe contraction and expansion. Actual installations are also shown and explained. Comparison data with other methods of expansion-contraction control is given. Barco Manufacturing Co.

Circle E14 green card, last page

WIEDEKE

THE QUALITY NAME IN TUBE EXPANDERS . . . SINCE 1892

Tube Expanders for Refinery Installations

Series 7000—with knurled handle, specified for rolling tubes parallel in tube seat and flaring ends in refinery fittings machined with flare angle 10° to 20° from center line.

Series 8000—with thrust collar preferred for rolling tubes parallel in tube seat and flaring ends in refinery fittings machined with flare angle of 7½° or less.

Series 9000—with thrust collar, used for rolling tubes parallel in tube seat of refinery fittings with tube stop, no flare.

#39

IDEAL

Specialization since 1892 in the manufacture of Tube Expanders, Tube Cutters and Operating Accessories provide the right answers to your tube installation and maintenance problems. Write for our new General Catalog 81.

The Gustav WIEDEKE Company

Dayton 1, Ohio

Freon Cylinder Sounds Horn When Fire Is Detected

New U/L approved automatic fire detectors, featuring individual and multiple unit installation, have now been designed.

Both single-station units and system installations are equipped with a new powerful diaphragm horn that sounds a five minute warning, audible up to one-half mile and more.

Individual units are completely self-contained. System installation permits an unlimited number of detectors to be arranged in a single, tubing-connected series. Individual and system detectors may be placed in critical areas and the horn mounted in any location convenient to watchmen or other personnel.

Manual equipment for sounding fire drills, testing and other signalling uses, may be easily added without disturbing the automatic operation.

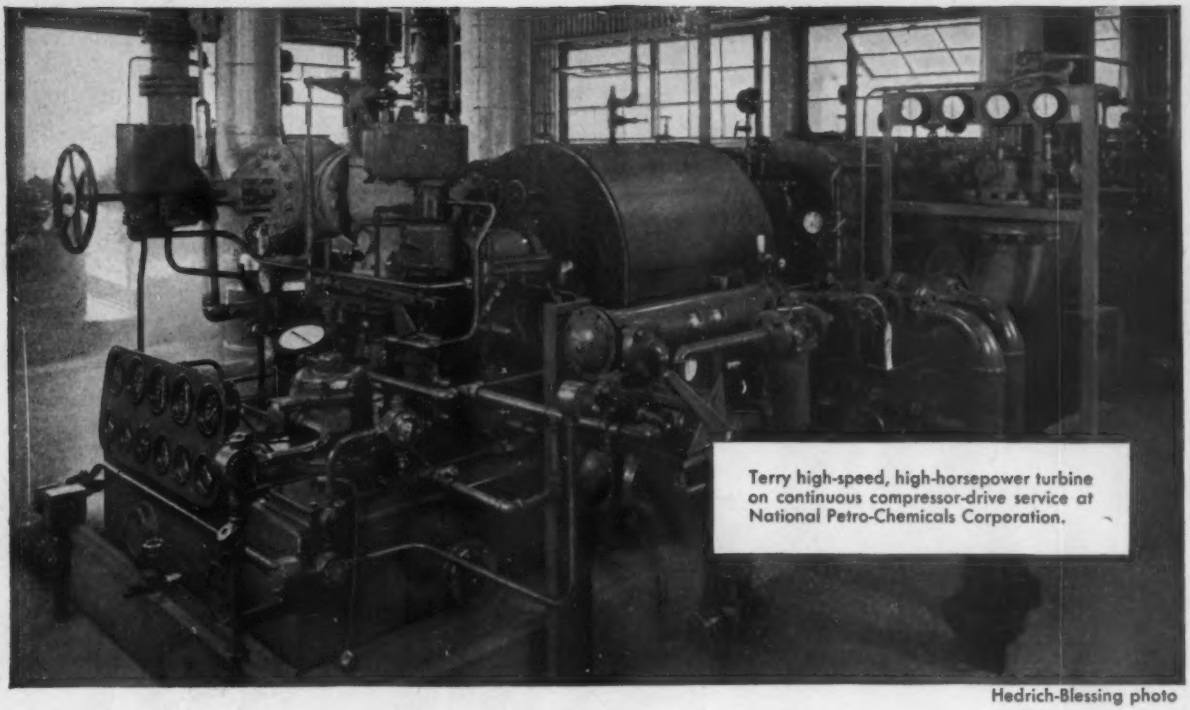
The power charge of Freon gas contained in the detector cylinder, is released to sound the horn when temperatures reach activation point. Detectors are available with temperature ratings of 136 F and 174 F and are more sensitive than corresponding standard sprinklers. Falcon Alarm Co. **Circle E15 green card, last page**

Tough Gasoline Can Now Be Sweetened With Inhibitor

Universal Oil Products Co. has announced the development and commercial availability of a new sweetening inhibitor which employs a selective catalyst to promote more rapid oxidation of sulfur compounds in gasoline.

The new product is UOP No. 5-S. The formulation, the company said, has been proved in laboratory tests and commercial usage to be even better than previous inhibitors for applications where inhibitor sweetening is the controlling factor in the choice of inhibitor used.

Retaining the potency and water-insolu-

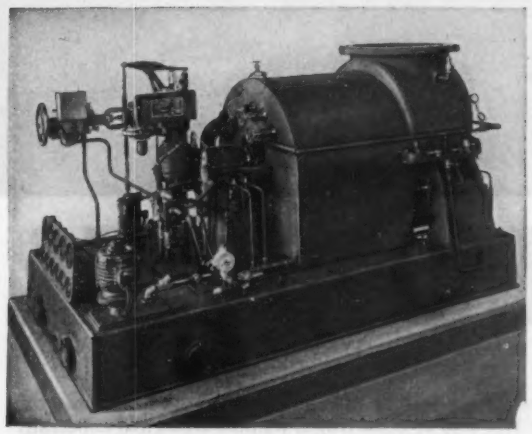


Terry high-speed, high-horsepower turbine on continuous compressor-drive service at National Petro-Chemicals Corporation.

Hedrich-Blessing photo

At National Petro-Chemicals Corporation . . .

Terry high-speed compressor-drive turbines provide continuous 'round-the-clock service



One of the two 5400 hp., 7486 rpm turbines built for the Tuscola plant of National Petro-Chemicals Corporation.

In the fall of 1953, five Terry multistage turbines were placed on day-and-night duty at the Tuscola, Illinois, Plant of National Petro-Chemicals Corporation. They drive high-speed compressors used to compress hydrocarbon gases in the production of ethylene.

The *excellent performance of these initial units later resulted in the installation of two more Terry machines.* These were placed in service some two years later.

In all, the seven turbines total more than 30,000 hp. They range in capacity from 3300 to 5400 hp., and in speed from 7500 to 9700 rpm.

The National Petro-Chemicals installation, and the thousands of other units serving in refineries and chemical plants throughout the world, are testimony to the low maintenance and consistent reliability of Terry turbines. Put Terry to work for you. Write for further information.

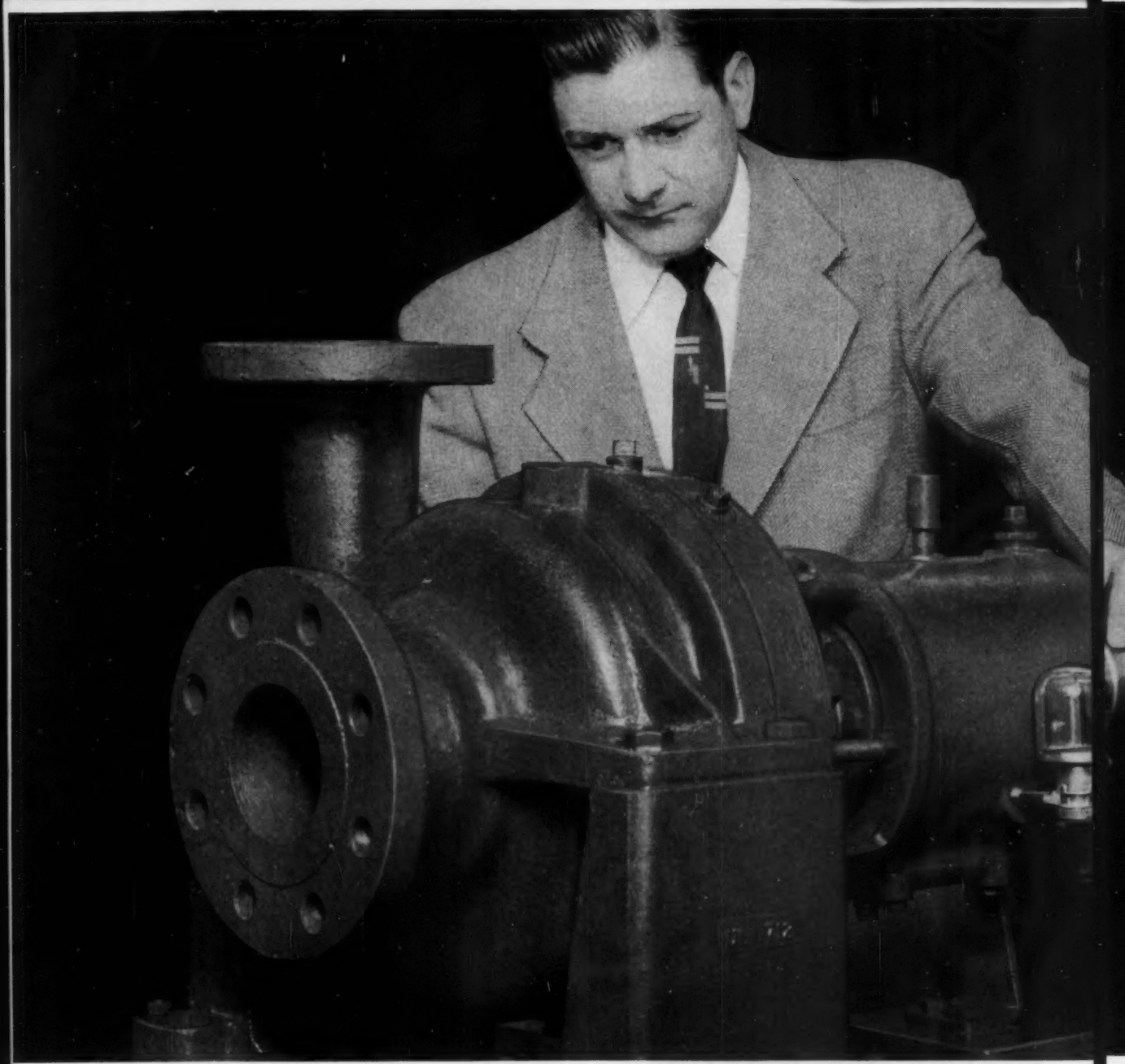
THE TERRY STEAM TURBINE CO.

TERRY SQUARE, HARTFORD 1, CONN.

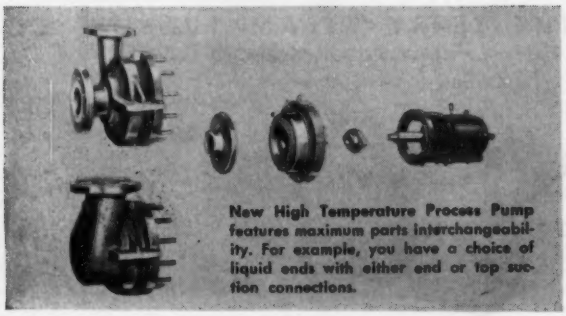
TERRY

TT-1207

For more data on advertised products, use Readers' Service Cards, last page.



NOW! A LOWER COST ALL-



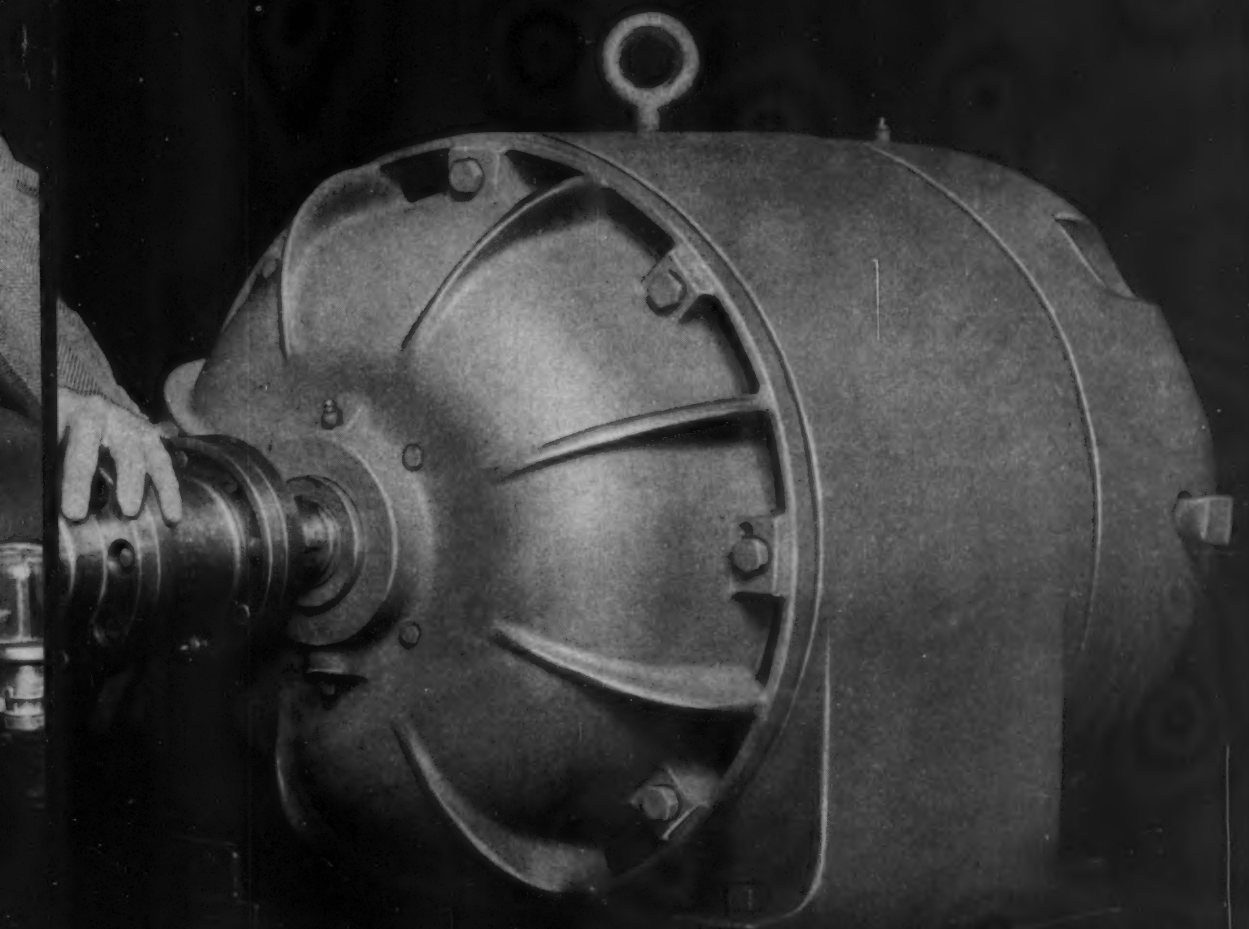
New High Temperature Process Pump features maximum parts interchangeability. For example, you have a choice of liquid ends with either end or top suction connections.

Here is the latest product of Worthington research – the new HN line of centrifugal pumps. Designed especially for process industry pumping problems, these heavy-duty pumps can meet all operating conditions up to 850 F and 600 psig.

Versatility. The HN line allows you to choose exactly the right pump. There are three models available: the HN with end suction; the HNT with top suction; and the HNC with integral seal. You have a choice of stock materials of construction – and for those severe corrosive conditions special alloys can be provided. Stuffing boxes are suitable for packing or mechanical seals in full compliance with API specifications.

The integral seal pump gives you all the advantages

There's always **PUMP NEWS** from Worthington



SERVICE PROCESS PUMP

of mechanical seal operation and features a totally enclosed seal housing for safe disposal of leakage vapors. Only one size seal is required for all pumps.

The "built-in" versatility of the HN line gives you application flexibility that takes care of changing conditions and cuts operating costs.

Interchangeability. The entire HN line is built to the same basic design, thereby simplifying maintenance procedure and offering maximum parts interchangeability. Only two bearing assemblies are required for thirteen sizes of pumps. Pumps on the same bearing assembly use identical bearings, shafts, sleeves, and packing or mechanical seals. And end or top suction casings are completely interchangeable.

For more information about the versatile new HN pump, or other units in Worthington's complete line of centrifugal pumps, get in touch with your nearest Worthington District Office. Or write to Section C-74, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Brantford, Ont.

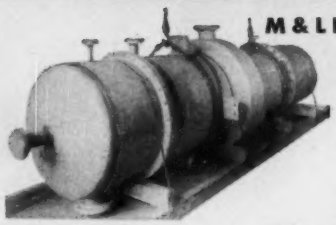
WORTHINGTON

MANNING & LEWIS ENGINEERING CO.
28-42 OGDEN ST. NEWARK 4, N.J.
WORKING PRESS:- SHELL TUBES
UNIT NO. JOB NO.

HEAT EXCHANGE and PROCESS EQUIPMENT

THIS NAMEPLATE IS YOUR GUARANTEE OF QUALITY

- Condensers
- Evaporators
- Jacketed Kettles
- Ribbon Mixers
- Agitators
- Reactors
- Pressure Vessels
- Heat Exchangers
- Reboilers



M & L HEAT EXCHANGER

CODE CONSTRUCTION: A.S.M.E.

MATERIALS: #316 Stainless steel tubes, tube sheets and heads.

PHYSICAL DIMENSIONS: Total surface: 1600 sq. ft. Shell O.D. 44" - over 400 1½" tubes - Expansion joint O.D. 57". Over-all length: 19' 6"

DESIGN WORKING PRESSURE: Shell Side - 90 lbs. Tube Side - 50 lbs.

Here is another example, among the thousands of case histories in our files, of how Manning & Lewis clearly and logically interpret customers' requirements . . . from original concept to finished quality product.

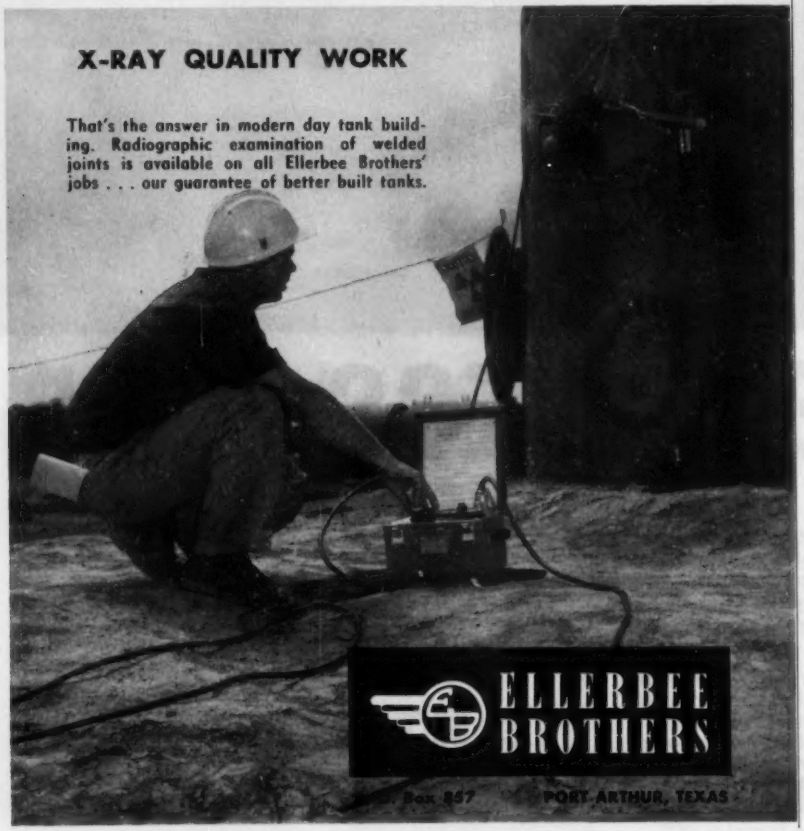
Both the saving in time and cost resulting from our years of engineering experience are two important factors why more and more manufacturers are turning to M & L.

Why not call on us the next time you need equipment. We design and construct to A.S.M.E. or A.P.I. code or we can build to non-code standards.

Please state *all* conditions of service so that we will be able to handle your inquiry promptly and accurately.

Manning & Lewis Engineering Company
DESIGNERS & MANUFACTURERS OF QUALITY HEAT EXCHANGE EQUIPMENT
28-42 OGDEN STREET NEWARK 4, NEW JERSEY

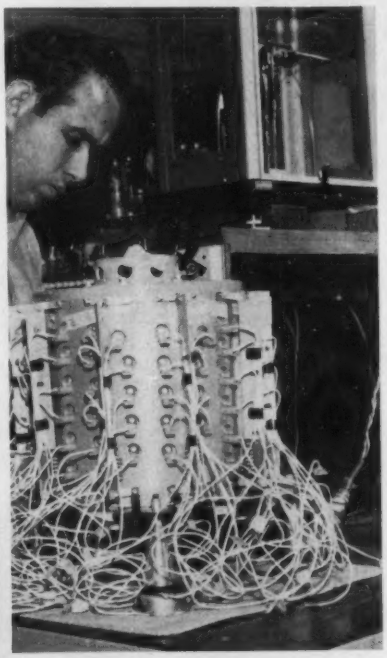
M&L


X-RAY QUALITY WORK
That's the answer in modern day tank building. Radiographic examination of welded joints is available on all Ellerbee Brothers' jobs . . . our guarantee of better built tanks.
ELLERBEE BROTHERS
Box 857 PORT ARTHUR, TEXAS

New Equipment . . .

bility characteristics of UOP No. 5 Inhibitor, the new additive accomplishes sweetening in one-fourth to three-fourths the time ordinarily required with UOP No. 5 depending upon the mercaptan content and other conditions. The new inhibitor now makes it possible to readily sweeten many gasolines which heretofore had been considered impractical for inhibitor sweetening. Universal Oil Products Co.

Circle E16 green card, last page



New Computer Has Amazing Memory

Fully automatic control for industrial process plants will now be possible for the first time through use of a new digital control computer just developed.

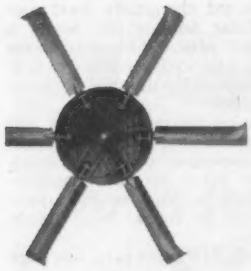
The revolutionary new computer is known as the RW-300 and has been specifically designed to automatically control industrial processes such as oil refining and a wide variety of other manufacturing processes.

The RW-300 is a general-purpose, magnetic drum storage, stored program serial machine. When used as a central unit of a process control system, it can automatically read process instruments, perform the computations necessary to relate these readings to process objectives, determine the control actions that will result in optimum plant operation, and activate process mechanisms or adjust set points on supervised control loops.

Incorporated within the RW-300 are integral input-output buffering, selection, and analog-digital conversion equipment, allowing it to be connected directly to process instruments and control devices. It can accept inputs from practically any kind of process instrument. Input-output capacity can be adjusted to the requirements or processes of any degree of complexity. Standard typewriter and punched

"HIGH and mighty"

move mountains - of AIR!
in towers and exchangers



Developed originally for the petroleum industry, Aerovent Large-Diameter "Al-metal" Propellers, constructed of tough, durable aluminum alloy, move great quantities of air at high velocities, in heat exchangers and cooling towers. Pictured above are two 4-blade, 16-ft. propellers in a cooling tower installation. These mighty propellers, with adjustable-pitch "Macheta" Airfoil blades, are job-engineered to individual specifications.

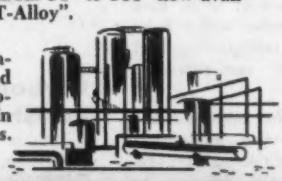
- Sizes 14' to 18'
- 4 or 6 blades

Write for free Bulletin 510

DESIGNED FOR DEPENDABLE OPERATION!

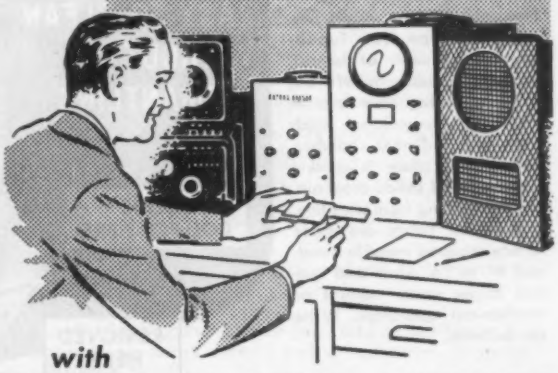
Endurance tests, conducted at *3 times* normal loading prove the ability of these new large-diameter propellers to withstand severe punishment. Heavy-duty cast steel hubs offer maximum resistance to stresses. Angle settings for each operating requirement, and appropriate alternate settings, assure accurate pitch for any predetermined performance which may be required. 54" to 144" now available in revolutionary new "T-Alloy".

REFINERIES, pumping stations, industrial plants and commercial buildings use Aerovent "Al-metal" Propellers in major air-moving applications.



Aerovent FAN COMPANY, INC.
LARGE PROPELLER DIVISION
304 Wright Bldg.
TULSA 3, OKLA.
Main Office and Factory
PIQUA, OHIO

STOP
EXHAUST NOISE and PIPING VIBRATION



with
BURGESS-MANNING SNUBBERS

Burgess-Manning engineers have spent years of scientific research into the cause and nature of exhaust noise and pipe line vibration. Out of this research came the Burgess-Manning Snubbing Principle.

Throughout the world, Burgess-Manning Snubbers, utilizing this unique principle, are eliminating the deafening, efficiency-reducing roar of engine exhaust and the destructive effects of pipe system vibration and pulsation where compressible gases are pumped.

Engineered by specialists for the specific applications, Burgess-Manning Snubbers pay for themselves in increased efficiency of equipment and personnel, lowered maintenance costs, improved labor and neighborhood relations.

This engineering service, with years of experience in the elimination of noise and vibration, is available for consultation on your problem without obligation.

Write for copies of case histories of typical installations.

Present your problems for Analysis and Recommendations

BURGESS-MANNING COMPANY
Sound Engineering
711 East Park Avenue, Libertyville, Illinois
Dallas, Texas

For more data on advertised products, use Readers' Service Cards, last page.

for Air or Gases containing Solids

install

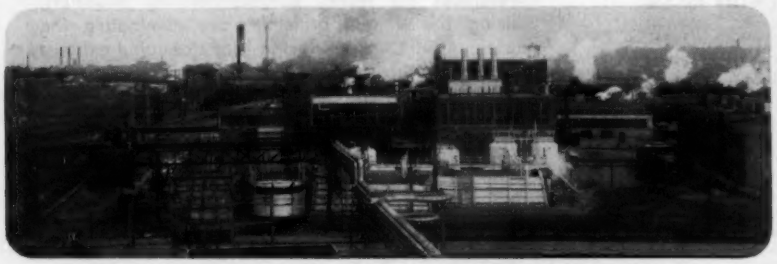
KWIKLEEN VALVES

Not only do these valves provide full pipe flow (unobstructed by seats or bends), as well as quick shut-off, but they minimize time loss in cleaning. Accumulated solids drop into sediment chamber. Bottom end plate is quickly removed and solids drop out. No dismantling from pipe line.

Kwikleen Valves are made of any required metal in standard 4" to 16" sizes and special larger sizes; manual or mechanical operators. Write for bulletin.

W. S. ROCKWELL COMPANY — 2367 Eliot Street, Fairfield, Connecticut

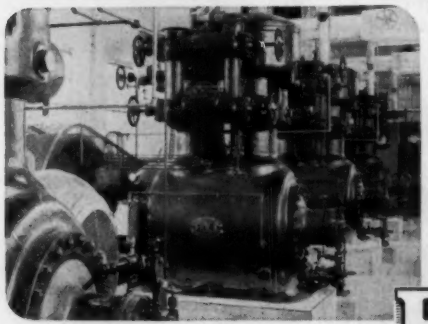
BUTTERFLY VALVES • SLIDE VALVES • AUTOMATIC VALVES



GOODYEAR'S NEW CHEMIGUM PLANT EQUIPPED WITH FRICK REFRIGERATION

This versatile plant, just completed at Akron, makes many types of rubber, latices and plastics. The big reactors, each holding 3000 gallons, are lined with glass; each is cooled with seven banks of glass-coated ammonia coils of the patented Frick direct-expansion design.

These coils, with their control system, enjoy a world-wide preference for use in chemical reactors.



Frick ammonia compressors at Goodyear's new plant in Akron, Ohio.

Four Frick compressors of 12 in. bore and 12 in. stroke, together with a 5 by 5 machine, carry the refrigerating load under automatic and semi-automatic controls.

When you want the most durable and efficient refrigerating equipment, whether for air conditioning, process work, ice making, quick freezing or other cooling service, specify "Frick". Literature and estimates on request.

DEPENDABLE REFRIGERATION SINCE 1882

FRICK CO.

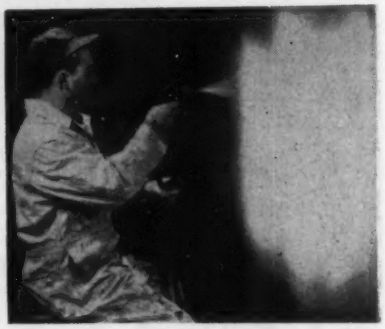
WAYNESBORO, PENNA., U. S. A.

New Equipment . . .

paper tape input and output are provided.

The Magnetic "Memory" Drum (shown in photo) of the RW-300 digital control computer provides large storage capacity (almost 8000 words) and allows several programs to be stored. The drum revolves at 3600 rpm. The Ramo-Wooldridge Corp.

Circle E17 green card, last page



Colored Resin Sticks To Black Bituminous Coating

A new Color Coat, number 261, is now available that will stick to and cover black bituminous coatings, old or new, as well as concrete, brick, cinder block, porous roofing tile, asbestos shingles, stucco—and properly primed wood and metal. Drying time is approximately 30 minutes.

A modified acrylic resin dispersion combined with selected chemically inert pigments, Color Coat number 261 leaves a tough pigmented plastic film that flexes with expansion and construction of base material. It is especially suitable for color keying service lines.

Color Coat takes weather in stride, and also shows remarkable resistance to sunlight, gases, corrosive fumes, cleaning compounds and many solvents. Application is economical by conventional spray equipment, brush or roller. Insul-Mastic Corp. of America.

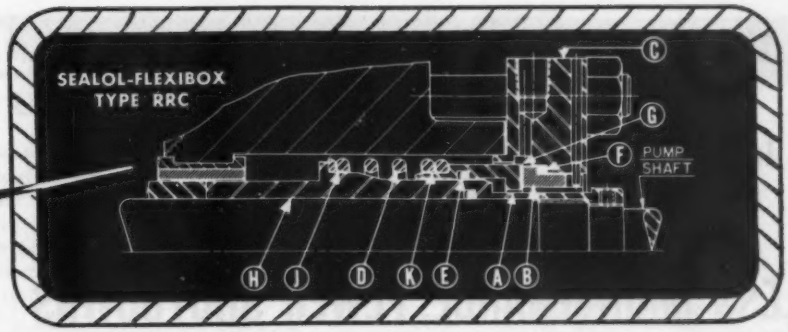
Circle E18 green card, last page

Carbon Saddle Packing Resists Thermal Shock

Intalox saddle packing is now available in carbon, according to an announcement just made. This new development in tower packings is the result of a joint research program of U. S. Stoneware and National Carbon Co. At present Carbon Intalox Saddles are being made in the 1-inch size only, but other sizes will be made available shortly.

These saddles are particularly recommended for use in operations involving

what is your SEAL IQ?



Q. Which are the rotating components of the above seal assembly?

A. In addition to the shaft; sleeve (H), drive spring (D), rotary seal ring (A), and rotary seal ring packing (E), all rotate with the shaft or rotor assembly.

Q. What turns the rotary seal ring?

A. Torque is applied uniformly through the unique Flexibox spring (D) by means of interference fits at points J and K. No pins or lugs are required.

Q. What is the suitable pressure range for the seal shown on the blackboard?

A. The design illustrated is a hydraulically balanced seal suitable for pressures up to 1000 psig.

Q. Where are the sealing faces?

A. Sealing faces are shown at point G where the rotary seal ring contacts the stationary seal ring face.

Q. How is the seal adjusted to set spring loading?

A. Integral sleeve (H) is designed to fit the pump and no adjustment or mechanical settings are necessary.

Q. How is frictional heat removed from the stuffing box cavity?

A. The Flexibox circulating type gland (C) provides product flow directly at the sealing faces.

Let Sealol Engineers solve *your* sealing problems on pumps, agitators, mixers and compressors. Request Bulletin No. 10.

SEALOL

THE ▲ BALANCED PRESSURE SEAL

SEALOL CORP
185 Post Road, Providence 5, R. I.

Baton Rouge • Chicago • Cleveland • Corpus Christi • Houston • Los Angeles
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Yes, we can handle your job...

SERVICE FOUNDRY

Our foundry and machine shop are geared to the special needs of the petroleum refining industry—and our production tools are the finest. As Avondale's foundry division, we have shared in the diversification and expansion of the industry as a whole. We are prepared to offer you a complete service—from engineering through the finished job. Next time, make it a point to call for "SERVICE" . . .

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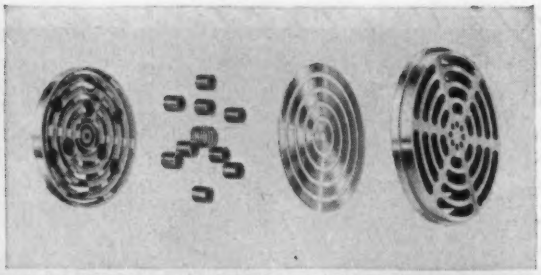
VOSS VALVES
in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS
for your compressor. (air, gas, ammonia)

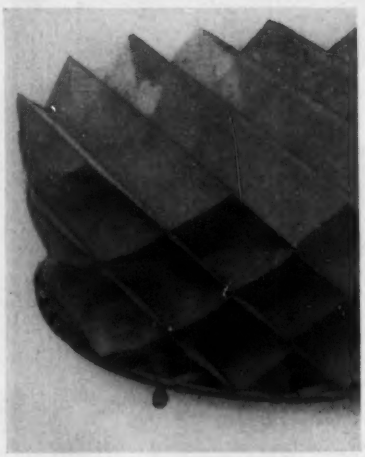
- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast) — VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.
J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

SINGLE LAYER PANAPAK PACKING



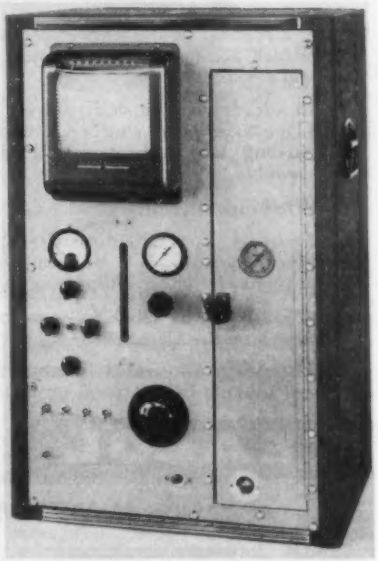
LOW COST
HIGH CAPACITY
FAVORABLE H. E. T. P.

Bulletin and additional information on request

PACKED COLUMN CORP.
PACKED COLUMN CORPORATION
30 Church Street, New York 7, N. Y.
A Column Packing For Every Application

New Equipment . . .

hot alkalies, mixtures of hydrofluoric and sulfuric acids, or hydrofluoric and phosphoric acids—applications where chemical ceramics would prove unsuitable. Their low co-efficient of thermal expansion enables them to be used under conditions of abrupt temperature change without danger of spalling. The U. S. Stoneware Co. **Circle E19 green card, last page**



Chromatography Analyzer Low Temperature Sensitive

A new high flexibility gas chromatography analyzer is now offered for laboratory use. It incorporates many flexibility features which fit it for a wide range of analyses. The instrument has built-in circuitry for either filament-element or ultra-sensitive thermistor-element detectors. The use of a high resistance filament-element detector provides high stability and very adequate sensitivity for normal analyses. The use of a thermistor-element detector provides extreme sensitivity at lower temperatures plus resistance to chemical attack.

Low temperature separations are possible by the use of the CHROMAT-O-FLEX auxiliary analyzer which incorporates an ice bath, carrier gas system, and complete detection system. The detector output may be connected to the model 1 recorder. Ambient temperature separations may also be run with this instrument. Loe Engineering Co.
Circle E20 green card, last page

Properties of Corrosion-Resistant Alloys Described

A new 104-page edition of "Hastelloy Corrosion-Resistant Alloys" is now available. The booklet gives up-to-date information on the four nickel-base alloys—Hastelloy alloys B, C, D and F.

The booklet describes chemical compositions, physical, mechanical, and high-temperature properties of the alloys. Also included is a table of the comparative resistance of the Hastelloy alloys to over 250 corrosives commonly handled in the

POSEY LARGE O. D. PIPE

For Specialized Uses In Oil Refineries

- CARBON STEEL
- STAINLESS STEEL
- NICKEL CLAD
- STAINLESS CLAD
- MONEL CLAD
- WROUGHT IRON

Posey has the experience as well as the facilities for fabricating almost any type of pipe from 20" diameter and larger. You can trust Posey to meet your most rigid specifications . . . with special attention to budget and delivery requirements. Write for complete information without obligation.

Fabricated in accordance with ASTM Specifications, Class A252-46

ELEVATED TANKS • HORIZONTAL TANKS • STACKS • PRESSURE VESSELS
DIGESTERS • CARBON STEEL AND ALLOY STEEL PLATE FABRICATION

POSEY IRON WORKS, INC.

STEEL PLATE DIVISION — LANCASTER, PENNA
NEW YORK OFFICE: GRAYBAR BLDG. — ESTABLISHED 1910

YEL ⊖ BAK

Industrial THERMOMETERS

Flat Bore—Mercury Filled—Engraved Stem—with 18-8 stainless steel stems. Chromium-plated case to resist corrosion and dirt. These midget industrial thermometers are recommended for equipment requiring Small Armored thermometers . . . and where large industrial thermometers are inappropriate.

An economical instrument . . . because thermometers may be replaced "on the job" . . . that is—refill can be inserted into Armored Case without difficulty . . . eliminates necessity of sending instrument to factory for thermometer replacement. Assured Accuracy.

THE RS COMPANY

REFINERY SUPPLY COMPANY

621 East Fourth Street · Tulsa 3, Oklahoma
2215 McKinney Avenue · Houston 3, Texas

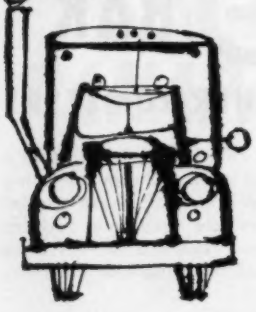
cenco

CENTRAL SCIENTIFIC COMPANY

1700 Irving Park Road · Chicago 13, Illinois

For more data on advertised products, use Readers' Service Cards, last page.

pull more diesels to your pump –deliver full power without noxious exhaust odors –just add Alamask® to your diesel fuels



It takes very little Alamask to subtract the choking odor from diesel exhaust fumes while adding to your sales. Alamask in your fuel will pull truckers, bus operators to your pump. *Selling point to truckers:* operators who tank up with your odor-controlled diesel fuels avoid the increasing demands to "put a stop to engine odors or reroute your lines." *Selling point for buses:* lines that standardize on your odor-controlled fuel increase passenger comfort both in the vehicle and in the terminal—builds good will all along the route. Why not call us about adding Alamask to your diesel fuels? Let us show you how Alamask can give you a new competitive plus.

RHODIA INC.

60 EAST 56TH STREET, NEW YORK 22, N.Y.
(PHONE PL. 3-4850) REPRESENTATIVES IN:
PHILADELPHIA · CINCINNATI · CHICAGO
DENVER · LOS ANGELES · MONTREAL · MEXICO CITY

New Equipment . . .

chemical, petroleum, paper and pulp, pharmaceutical, and metalworking industries.

More complete laboratory penetration data are included for some of the common corrosives such as hydrochloric, sulphuric, nitric, phosphoric, acetic and formic acids. These data are supplemented with graphs showing penetration rates at various acid concentrations and temperatures. Haynes Stellite Co.

Circle E21 green card, last page

Straddle Carrier Also Used As Mobile Crane

Combining the normal duties of a straddle carrier and a mobile crane, this new unit features a hydraulic crane with 180 degree swing, extendable arm from 5 feet, 6 inches up to 15 feet, 9 inches. Operated by one man, the unit can load or unload in a matter of seconds; and with speeds

To watch a melt . . . or roast a chemical

If you have a job that glass should do, but no ordinary glass is tough enough, it's probably a job for a VYCOR brand glass.

With seething molten metal on the other side of your sight glass, boiling acids, or inflammable oil . . . where your firing operations include extreme temperatures up to 1100° C. . . . or extremely high dielectric strength . . . you want VYCOR brand glass.

There are 7 VYCOR brand glasses with a wide range of unusual properties. All are 96% silica.

Glass 7900 is the basic VYCOR glass and can be used at continuous operating temperatures of 900° C. Glass 7910 gives ultraviolet transmittance at 254 millimicrons and is used in germicidal lamp applications. Glass 7911 has high electrical resistivity and low power loss. Glass 7912 has high ultraviolet transmittance to below 185 millimicrons. Glass 7913 has the greatest heat resistance of all, permitting intermittent use at temperatures as high as 1100° C. Glass 7930 is the porous form known as thirsty glass. Glass 7950 is red-stained to absorb visible light while transmitting infrared.

Wondering where you can use this remarkable glass?

"VYCOR brand Industrial Glassware by Corning" . . . contains charts, tables, and complete information about these unique glasses, and suggests many applications.

CORNING GLASS WORKS
96-9 CRYSTAL STREET, CORNING, N. Y.
Corning means research in Glass

Plibrico **Refractories**

THE *"pro"* OF *proper* PRODUCTS

There's nothing amateurish about the way Plibrico refractories get the job done. That's because there are no cure-all refractories in the Plibrico line, but rather specific types and grades tailored to lining process equipment.

Here, in brief, are a few for your work.

Plicast Verilite—a light weight insulating castable of unusual characteristics, combining low "K" factor and utmost strength. Made for pneumatic application.

Plicast Petromix (Tuff-Mix G)—a first quality dense castable specifically designed for early strength in the intermediate temperature range (1000-1500 deg. F.), and for pneumatic application.

Plicast 40—one of seven abrasion resistant castables. Designed for low iron service requirements in extreme conditions. For trowel or pneumatic application.

Ask your Plibrico man for complete details. Write, too, for our catalog covering your applications.

Plibrico REFRACTORIES ENGINEERING CONSTRUCTION

PLIBRICO COMPANY • CHICAGO 14, ILL.
Plibrico Sales & Service in Principal Cities

As SIMPLE and Dependable as the Pull of a MAGNET!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.

MAGNETROL

The Simplest, Most Versatile LIQUID LEVEL CONTROL Ever Devised!

Linked to liquid level by infallible magnetic force, Magnetrol is free from the limitations inherent in mechanical or electrical controls. With the actuating magnet rated at 98% of initial strength after 30 years, Magnetrol has *infinite operating life,* with practically no maintenance at all. There are no wearing parts to get out of order.

What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

MAGNETROL, Inc.

● SEND COUPON FOR DETAILS

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Please send me catalog data and full information on Magnetrol Liquid Level Controls.

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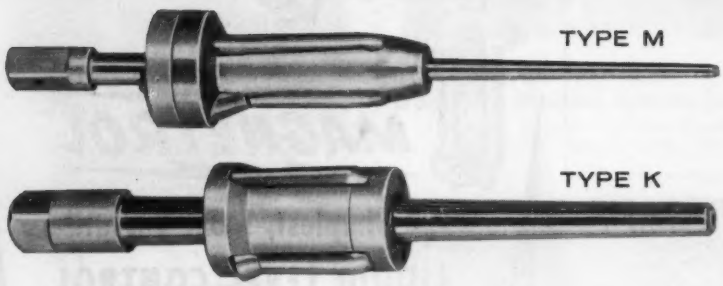
For more data on advertised products, use Readers' Service Cards, last page.

write for your copy of this Bulletin!

ELLIOTT
Boiler Tube Expanders
for tubes 3/4 in. I.D. and up



This 16-page bulletin describes general types of Elliott boiler tube expanders for fast, efficient tube rolling jobs. It also gives dimensions, prices and other descriptive data and shows various drum, header and short series mandrels which are used with Elliott boiler tube expanders. Drum mandrels are seen with Type M and Type K above.

Accessories available to adapt Elliott boiler tube expanders to various tube rolling applications include universal joints and extension shafts, sockets, gear drives, etc. A new heavy-duty, right-angle gear drive utilizes roller bearings to minimize friction, cutting down power losses.

RIGHT-ANGLE GEAR DRIVE▸
Available in ½, ¾ and 1-in. sizes

Write the Elliott Company, Lagonda Division, Springfield, Ohio, *today*, for your copy of Bulletin Y-46.

Y7-5

ELLIOTT Company
For Tube Cleaners, Expanders and Accessories

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS • CENTRIFUGAL COMPRESSORS • TURBOCHARGERS • TUBE CLEANERS • STRAINERS

New Equipment . . .

up to thirty miles an hour it provides rapid and efficient transport between two points. Capacity five tons, it will take a one in seven gradient fully loaded. For pipe-laying, pipe transported to the site by the carrier can be removed individually by the crane and lowered directly into the trench if required. Unit is available with either gasoline or diesel engine power. British Straddle Carrier Co., Ltd.

Circle E22 green card, last page

Cylindrical Slide Rule Has Accuracy of 66 Incher

A new edition of "What's New for the Laboratory"—29th in the series—has just been announced.

Among the new items illustrated and described in this 16-page issue is a 6 inch x 1¼ inch diameter cylindrical slide rule which has the accuracy of a 66 inch linear slide rule. Scientific Glass Apparatus Co. **Circle E23 green card, last page**

Hot Spray Package Unit Is Self-Contained and Portable

Completely self contained, this unit combines a hot spray heater and reciprocating pump in a portable unit which carries the original five or ten gallon paint container. It is especially designed for industrial and maintenance painting requirements where long hose lines and portability are required.

The mobile Chieftain meets maintenance needs by providing hot spray temperatures for one or two guns and on hose lines up to 75 feet in length.

Equipped with the U.L. approved Spee-Flo hot spray heater and divorced action pump, circulation from heater to gun is maintained for temperature control. The operator can select paint temperature by simply turning the controller. A single air and electrical connection places this complete spraying system in operation.

The 600 and 900 series models are equipped with a 2KW or a 3KW heater and a pump designed to spray up to a gallon per minute. A larger series Chief-

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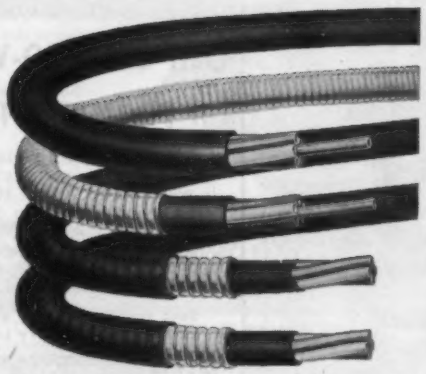
Solves Corrosion Problems For Instrument Tubing

In FOUR Corrosion Resistant Types

Type CT
Type CTA
Type CAT
Type CTAT



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Crescent Armored Multitube® consists of long-length copper, aluminum or polyethylene tubes twisted together to permit bending without distortion. In each layer, one tube is a bright blue color, affording a fast means of identification from both ends.

Type CT—For damp or corrosive locations where a moderate degree of mechanical protection to the tube is required. It employs a corrosion-resistant thermoplastic sheath, resistant to water, acids, alkalies, oil, and is flame-retardant.

Type CTA—Where maximum mechanical protection is desired during and after installation, such as direct burial in concrete and for pulling into conduit.

Type CAT—For protection against corrosion to the armor and to the tubing.

Type CTAT—Combining the advantages of Types CTA and CAT, the fourth type illustrated has the polyvinyl chloride thermoplastic sheath both under the armor and over the armor, thus providing maximum mechanical and corrosion protection.

Available in long runs from 2 to 37 tubes of copper, aluminum and polyethylene tubing in size ¼" O.D. This product is licensed under U. S. Patent No. 2,578,280.

Send for Bulletin No. 356-G

CRESCENT

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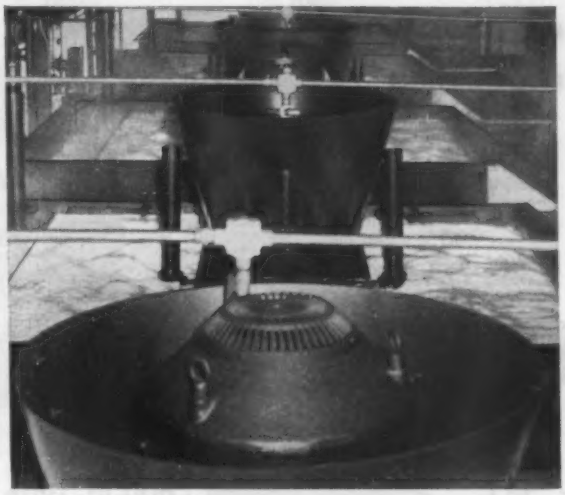
HENDRICK HYDRO-DEHAZER

removes haze from refinery oils in a hurry!



Here's a process that has been operating with a great deal of economy in several major refineries: The Hydro Dehazer's huge rotor mixes moisture-laden oil with free air until the moisture is absorbed by the air and discharged to atmosphere. The entire cycle achieves optimum efficiency without the use of compressed air, high heat, chemicals or other additives. Capacities range to 450 bph for No. 2 fuel oil at an inlet temperature of 130°F. with a haze point of 70° depending on the consistency of the charge.

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☐ Please send technical data.

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For more data on advertised products, use Readers' Service Cards, last page.

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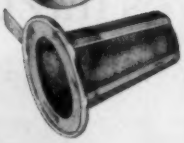

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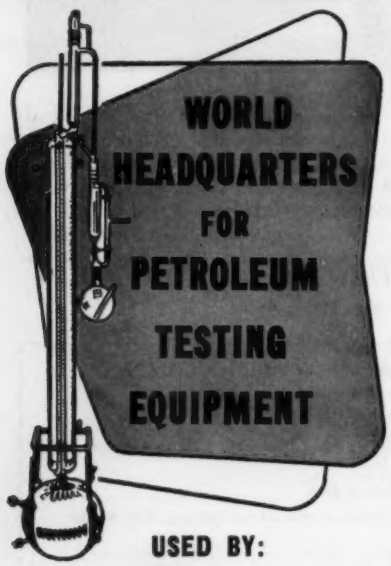

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New Equipment . . .

tain offers a similar assembly on a four wheeled cart and carries a 55 gallon paint drum. Spee-Flo Co.

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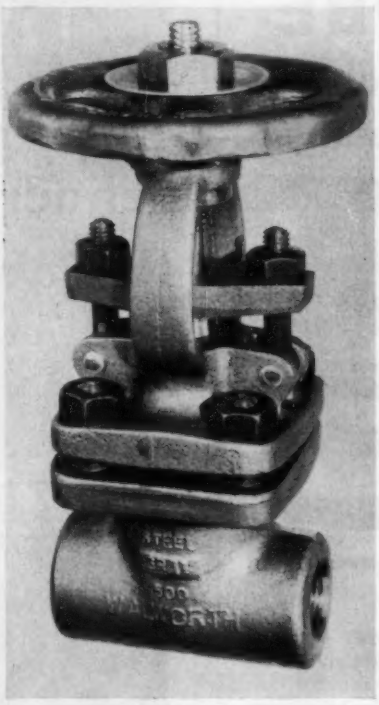


600 lb. Gate Valve for High Temperature Service

For water, steam, gas or air service at temperatures up to 850 F. and for oil or oil vapor up to 1000 F., a new line of 600-pound steel wedge gate valves has now been designed.

Valve body is of forged carbon steel. This valve has a non-shock pressure-temperature rating of 420 psi at 1000 F. and a rating of 2000 psi at 100 F. Stem, wedge and seat rings are made of 13 percent chromium stainless steel for longer service life. The wedge has a hardness of 500 Brinell and is accurately guided by ribs in the body.

All valves in the new line are of the outside screw and yoke design. These valves are designed to permit repacking under pressure when fully opened. Repacking is made easy by the curved yoke arms and swing type eyebolts which provide free access to the stuffing box.

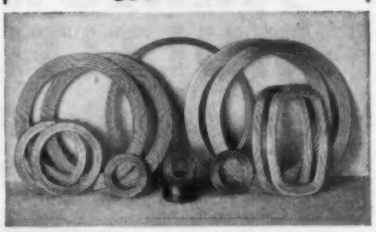
The valves are available with screwed or socket welding ends. Those with a union bonnet are available in eight sizes from one-fourth to two inches; those with bolted bonnets, in six sizes from one-half to two inches. Walworth Co.

Circle E25 green card, last page

Bulletin Guides Users Selecting pH Electrodes

A new eight-page bulletin features pH electrodes for laboratory and portable pH meters. The electrode bulletin is made up in unique, simplified chart-form, com-

Need Plain or Jacketed CORRUGATED METAL GASKETS?



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Chicago-Wilcox understands the gasket requirements of refineries and is equipped to supply all types of gaskets, including plain or jacketed corrugated metal gaskets like these. Made of ingot iron, aluminum, stainless steel, copper, brass, nickel, and monel in all sizes and shapes.

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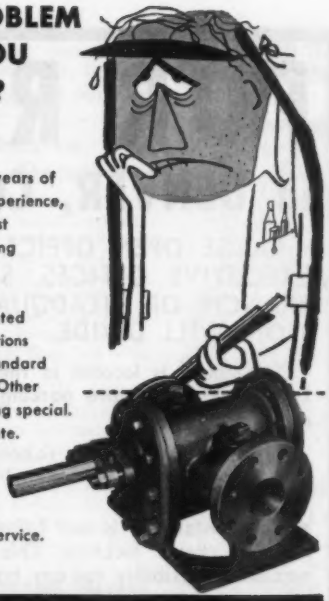

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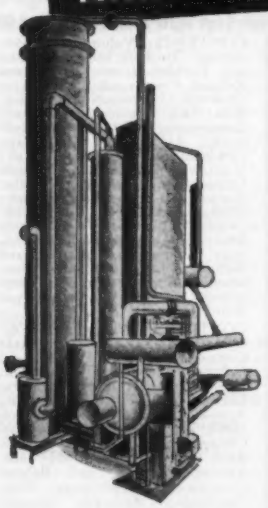
NEW! straub NITROGEN GENERATORS



STRAUB Nitrogen Generators are built as complete packaged units. Standard units are capable of producing up to 97% pure nitrogen—with accessory equipment practically 100% pure nitrogen can be made. This new line of compact, low cost generators are easy to operate and are equipped with all necessary control equipment and safety devices.

Be sure to get full details on STRAUB Nitrogen Generators—built in a standard range of capacities from 1500 to 20,000 C.F.H. Larger and smaller sizes are also available.

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C-5's exclusive colloidal copper formula separates mating metal threads and surfaces with cushioning, protective copper plating. C-5 prevents galvanic action and eliminates pitting even when dissimilar metals join. On mating metal surfaces, C-5 saves gaskets and countless man hours.

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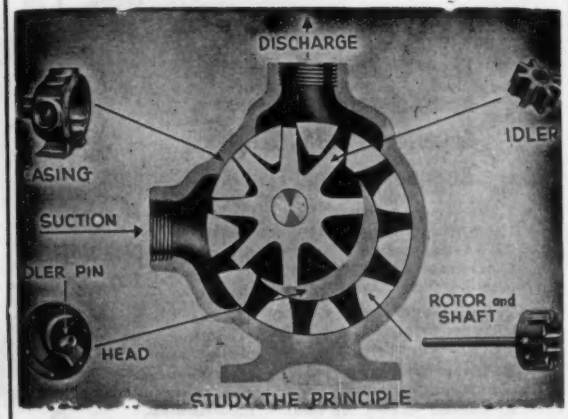
Viking Operating Principle



Above are illustrated the major parts of the Viking Pump—casing, head, rotor and idler, separately and assembled. Imagine the rotor and idler in motion operating in a counterclockwise direction. Follow the course of the liquid from point of suction to point of discharge. Reverse direction will operate equally well. We invite your inquiries.

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pletely indexed and illustrated—designed to guide users in selecting correct pH electrodes. Beckman Instruments, Inc.

Circle E26 green card, last page

Super Tough Adhesive Bonds Rubber to Metal

A new adhesive for bonding cured natural or synthetic rubber to metal provides a bond so strong that the rubber will tear before it can be peeled from the metal.

Cured in 24 hours at room temperature (77 F. minimum), Ray-BOND R-86001 reaches maximum strength after seven days. To reach maximum strength immediately, it may be cured in four hours at 120-140 F.

Seven-day immersion tests in 10 percent hydrochloric acid, 3 percent sulphuric acid, 10 percent ammonium hydroxide or 10 percent sodium hydroxide have shown no visible effect on the bond. Rubber linings under peel or shear stress can be bonded with the adhesive for use in temperatures up to 100 F. Dielectric strength is 400 to 450 volts per millimeter. Raybestos-Manhattan, Inc.

Circle E27 green card, last page

Brochure Reveals Toughness Of Moulded Insulation

A 16-page illustrated brochure on amosite, asbestos moulded thermal insulation materials (blocks and pipe sections) and complementary materials is the latest in the series of published technical sales literature.

Of interest are the photographs of a 'tumbler' test illustrating the toughness of moulded amosite pipe-sections, and the time and motion photographs showing how single layer fittings on a 4-inch pipe takes 55 seconds against 2 minutes 20 seconds for double layer fittings. The Cape Asbestos Co., Ltd.

Circle E28 green card, last page

Superior Gas Drying Agent Described In Brochure

A new technical brochure on molecular sieves is now available. Complete information is given on using molecular sieves as a superior drying agent for gases. Tables and charts provide engineering data for preliminary designs of low-dew-point drying systems.

Molecular sieves are a new class of adsorptive desiccants which offer unusually effective performance in commercial gas-drying operations.

The brochure has 20 pages and is triple punched for loose-leaf book filing. It is entitled "Dry Gas? Use Linde Molecular Sieves." Linde Co.

Circle E29 green card, last page

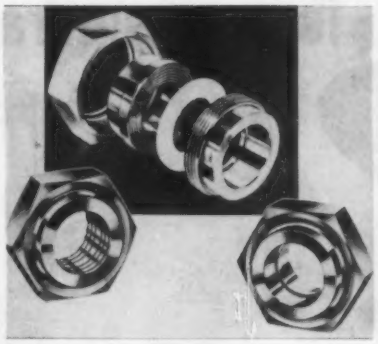
Data Sheet Describes Inhibitor Metering

Recently published is a new application engineering data sheet which describes two systems for metering sweeteners, inhibitors and metal deactivators to gasoline.

This two-page data sheet shows how electric or air-operated controlled volume pumps are employed in these systems. It illustrates methods for metering additives to individual storage tanks and continuous proportional metering to product streams. Milton Roy Co.

Circle E30 green card, last page

New Equipment . . .



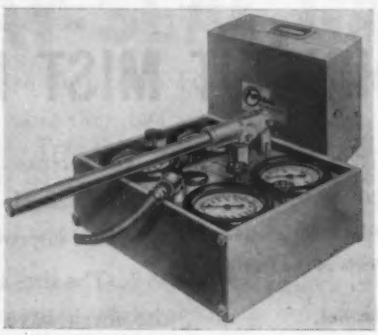
Stainless Steel Union Solves Common Leak Problem

A new and unique design of the speedline union for use with light wall schedules 5 and 10 stainless pipe provides a serrated face for the gasket material of your choice. The gasket eliminates the leakage that so frequently occurs with ground joint stainless unions.

Bi-metallic construction of stainless steel ferrules and cadmium plated carbon steel nut gives a union joint that can be made up and broken many times without the galling so typical of stainless threaded connections.

These unions are available in two types —for expanding in sizes one-half inch through one and one-half inch and for welding or brazing in sizes one-half inch through two inches. Larger sizes on application. Horace T. Potts Co.

Circle E31 green card, last page



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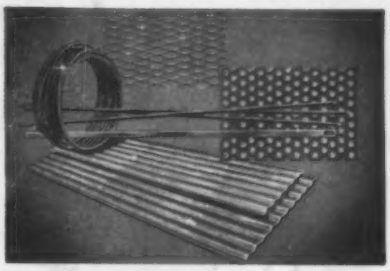

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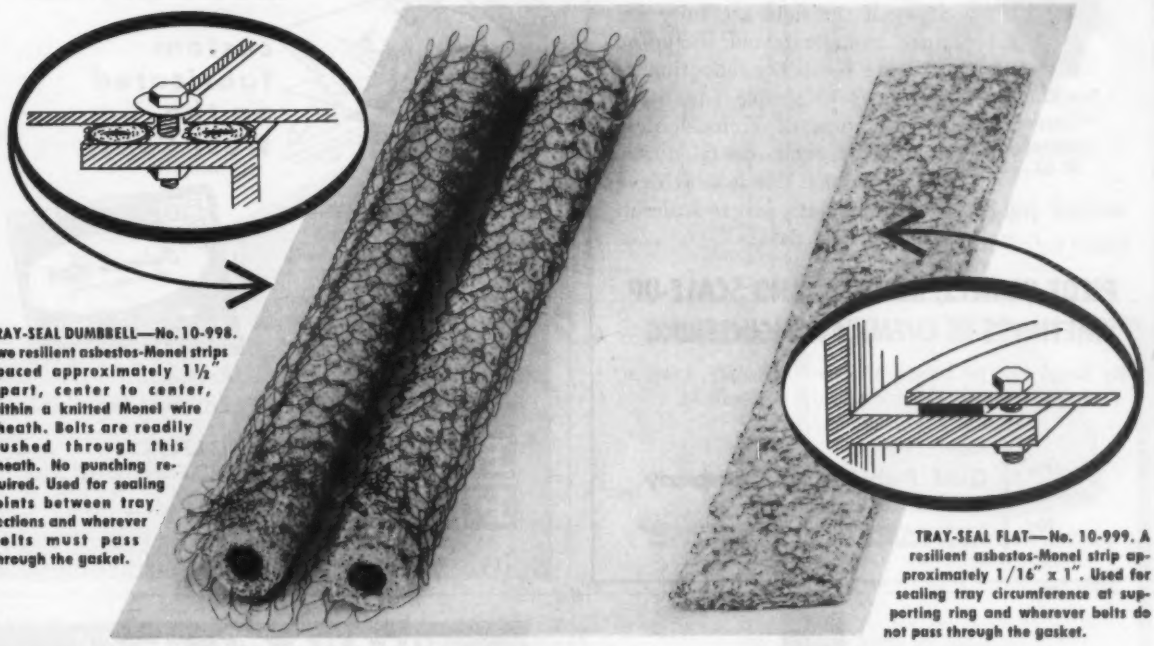

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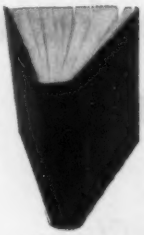

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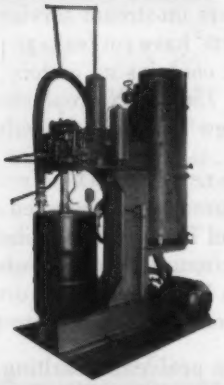

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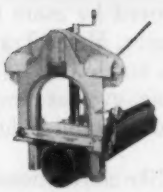

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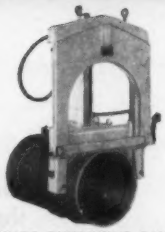

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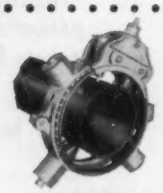

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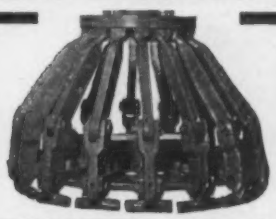

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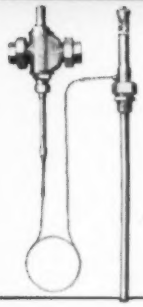
Low-cost Temperature Control — by SARCO

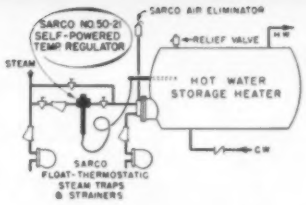
Self-Powered and Electric Indicating



Sarco Temperature Controllers
Self-Powered . . . Fully Modulating

Simple as ABC . . . a thermostat with capillary tubing and a valve. That's all! Operated by liquid expansion. Automatic. Self-powered . . . no electricity or compressed air required. Self-contained . . . no exposed mechanism. Packless valve . . . no stuffing box to leak or stick. Easy to install by any pipefitter.

Furnished with thermostats suitable for any liquid or for air in dryers, ovens, air ducts, etc. Valve sizes . . . ½ to 6". Temperature ranges to 300°F. *Bulletin 620-2.*

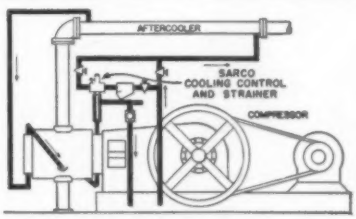


Typical applications: Shell and tube heat exchangers; condensers, oil storage tanks, dryers, etc.

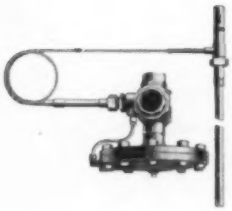
Sarco Cooling Controls
Self-Powered . . . Fully Modulating

Simple, compact, automatic thermostatic valve. Eliminates overcooling and undercooling. Saves water. Overall height of ¾" size is only 17 7/16". Self-powered . . . requires no electrical or compressed air hook-up. Valve and bulb all in one unit. No exposed mechanism. Single-seated packless valve . . . not affected by silt or scale-forming minerals.

Valve sizes . . . ⅜ to 1½". Temperature ranges between 40° and 210°F. *Bulletin No. 710-B.*



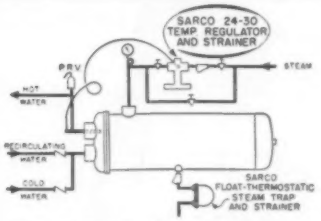
Typical applications: compressors, small engines, water-cooled bearings, condensers, dry cleaning stills, etc.



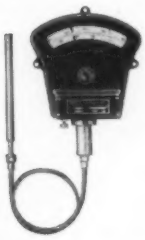
Sarco Temperature Controllers
Self-Powered . . . Single-Seated, Tight-Closing

A simple, self-powered automatic temperature controller with diaphragm-operated, pilot-controlled valve. Designed for intermittent service or service involving long periods with practically no call for steam. Self-powered by liquid expansion . . . no electricity or compressed air needed. Packless.

Valve sizes . . . ½ to 3". Temperature ranges to 300°F. *Bulletin No. 625-B.*



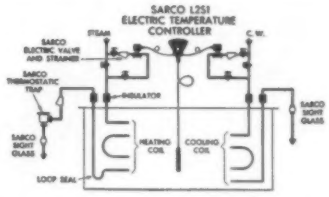
Typical applications: instantaneous heaters, fuel oil pre-heaters, high pressure applications on hot water storage tanks.



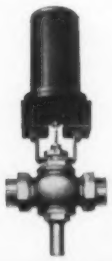
Sarco Electric Temperature Controllers
Indicating Type

Simple, inexpensive, electric-indicating automatic temperature controller. Sensitive enough to perform many of the functions of much more elaborate recorder-controllers, at a fraction of their cost. Responds to changes of ± ½°F. Adjustable. Large, easy-to-read scale shows both actual and set temperatures.

Temperature ranges between minus 90° and plus 650°F. Offers many sequence combinations such as step-heating. *Bulletin 1025-B.*



Typical applications: plating tanks, processing vats, kettles, chemical tanks, etc.



Sarcostat Hydraulic Motor Valves
Electrically Operated

For remote control by hand or thermostat. Open and shut operation. Can be equipped with semi-modulating mechanism. Powerful hydraulic action operates valves up to 5" single-seated, or 8" double-seated, at pressures up to 175 psi. Ruggedly constructed . . . to withstand severe use without constant supervision and with minimum maintenance. Operates in any position.

For direct connection to 110 volts A. C., 60 cycle current. Valve sizes . . . ½ to 5" single-seated; ½ to 6" double-seated. *Bulletin 1080-A.*

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From one "Complete Line" source . . . SARCO-SARCOTHERM . . . for temperature controllers, steam traps and other heating specialties.

2230-B

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